CARREL-ELECTRADE LTD

not just products... solutions!

TECHNICAL GUIDE FOR SENSORS

How Does a Capacitive Proximity Switch Work

Capacitive proximity sensors can be used to detect metallic and also non metallic targets like paper, wood, plastic, glass, wood, powder, liquid..etc without physical contact. The capacitive proximity sensor works on the capacitor principle. The main components of the capacitive proximity sensor are plate, oscillator, threshold detector and the output circuit.
The plate inside the sensor acts as one plate of the capacitor and the target acts as another plate and the air acts as the dielectric between the plates.
As the object comes close to the plate of the capacitor the capacitance increases and as the object moves away the capacitance decreases. The detector circuit checks the amplitude output from the oscillator and based on that the output switches.
The capacitive sensor can detect any targets whose dielectric constant is more than air

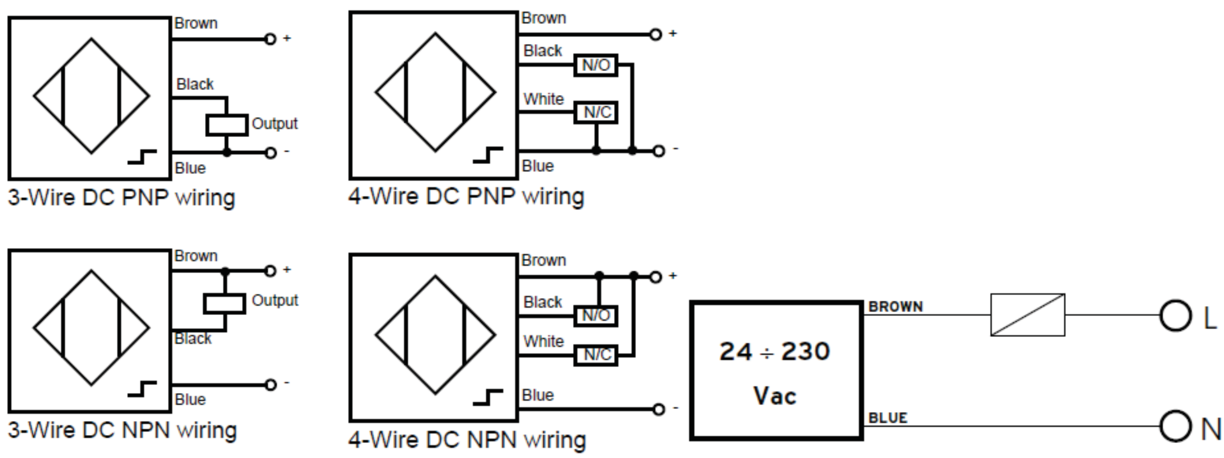
The advantages of capacitive sensor are

- It can detect both metallic and non metallic targets.
- Good stability
- High Speed
- Good Resolution
- Capacitive sensors are good in terms of power usage
- Low cost
- Available in N/O or N/C or both

The disadvantages of capacitive sensors are

- They are affected by temperature and humidity
- Could be triggered by dust, moisture..etc
- Sensitive to noise
- Difficulties in designing
- Linearity is not good
- Capacitive proximity sensors are not as accurate compare to inductive sensors.

Wiring types



How does an Inductive Proximity Switch Work

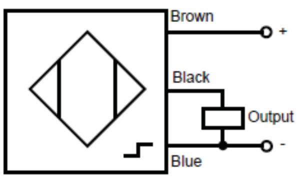
The inductive proximity sensor can be used to detect metallic targets only. The main components of the inductive proximity sensor are coil, oscillator, detector and the output circuit.
The coil generates the high frequency magnetic field in front of the face. When the metallic target comes in this magnetic field it absorbs some of the energy. Hence the oscillator field is affected. This is detected by the detector. if the oscillation amplitude reaches a certain threshold value the output switches.
The inductive proximity sensor works better with ferromagnetic targets as they absorb more energy compare to non Ferromagnetic materials. Hence operating distance for sensor is more for Ferromagnetic targets.

The advantages of inductive proximity sensors are

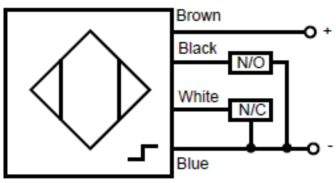
- They are very accurate compared to other technologies
- Have high switching rate
- Can work in harsh environmental conditions
- Available in N/O or N/C or both

The disadvantages of inductive proximity sensor are

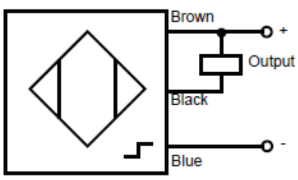
- It can detect only metallic targets
- Operating range may be limited



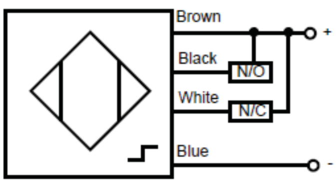
3-Wire DC PNP wiring



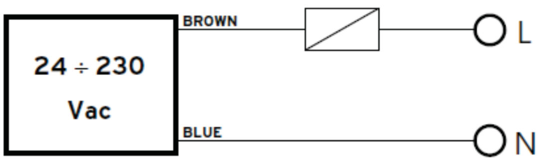
4-Wire DC PNP wiring



3-Wire DC NPN wiring



4-Wire DC NPN wiring

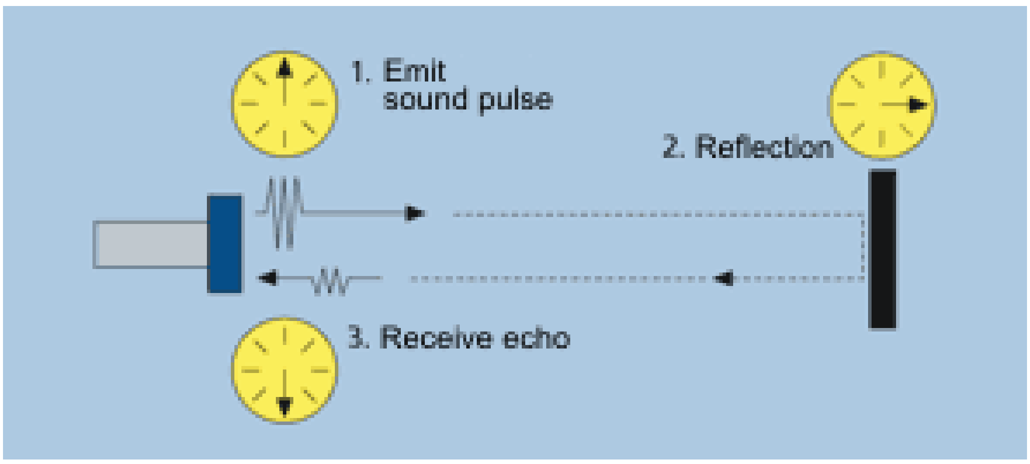


Ultrasonic principle - where high performance sounds good

Ultrasonic sensors have set new standards in automation

Ultrasonic principle:

- Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo.
- As the distance to an object is determined by measuring the time of flight and not by the intensity of the sound, ultrasonic sensors are excellent at suppressing background interference.
- Virtually all materials which reflect sound can be detected, regardless of their colour. Even transparent materials or thin foils represent no problem for an ultrasonic sensor.
- Microsonic ultrasonic sensors are suitable for target distances from 30 mm to 10 m and as they measure the time of flight they can ascertain a measurement with pinpoint accuracy. Some of our sensors can even resolve the signal to an accuracy of less than 0.18 mm.
- Ultrasonic sensors can see through dust-laden air and ink mists. Even thin deposits on the sensor membrane do not impair its function.
- Sensors with a blind zone of just 30 mm and an extremely narrow beam spread are finding totally new applications these days: measuring levels in yoghurt pots and test tubes as well as scanning small bottles in the packaging sector - no trouble for our sensors. Even thin wires are reliably detected.



Photoelectric Sensor Overview

The photoelectric family with the next longest sensing distance is called **retro-reflective sensors**, commonly referred to as a "retro". Retro--reflective sensors operate similarly to through-beams without being able to reach the same sensing distances. Certain units may still be used in applications needing ranges of up to 10 m. The similarity between retro-reflective and though beam photoelectrics is that there is a constant beam that needs to be broken in order for an output to occur. But, instead of having a separate housing for the emitter and receiver, they are both located in the same housing, facing the same general direction. The emitter produces a laser, infrared or visible light and projects the beam towards a specially designed reflector, which returns the beam, back to the receiver. .Detection occurs when the light path is broken or otherwise interfered with. If the output occurs when the beam is broken, the sensor would be considered a **dark-on photo.**

A reason one would specify a retro-reflective sensor over a through beam is because only one location needs to be wired for installation. The opposing side simply requires installation of the reflector. This could result in a big cost savings in both parts and time.

However, objects that are very shiny or highly reflective like a mirror, a can, or small juice box wrapped in clear plastic can provide a challenge to a retro-reflective photoelectric. These targets may reflect enough light to "trick " the sensor: because ample light is reflected from the object, the receiver may not recognize that the beam has been interrupted and the sensor does not identify that the target has passed. Some manufacturers have addressed this problem with a **polarization filter**, which allows only light reflected a specially designed reflector to be received, and not erroneous reflections from the target.

Diffuse sensors operate under a somewhat different style than retros and through-beams although the operating principle remains the same: diffuse photoelectrics actually use the target as the "reflector", such that detection occurs upon reflection of the light off the object back onto the receiver as opposed to an interruption of the beam. The emitter sends out a beam of light. Most often it is a pulsed infrared, visible red or laser beam, which is reflected by the target when it enters the detectable area. The beam is diffused off of the target in all directions. Part of the beam will actually return back to the receiver inside of the same housing in which the sensor originally emitted it from. Detection occurs and the output will either turn on or off (depending upon if it is Light On or Dark On) when sufficient light is reflected to the receiver. This can be commonly witnessed in airport washrooms, where a diffuse photo will detect your hands as they are placed under the faucet and the attending output will turn the water on. In this application, your hands act as the reflector.

Due to the operating principle of using the target as the reflector, diffuse photoelectrics are often at the mercy of target material and surface properties; a non-reflective target such as matte-black paper will have a significantly decreased sensing range as compared to a bright white target. But, what seems as a drawback on the surface can actually be a benefit in practice. Because diffuse sensors are somewhat color dependant, certain versions are suitable for distinguishing dark and light targets in applications that require sorting by contrast or quality control. Specialty versions of diffuse sensors are even capable of detecting different colors. Also, with only the sensor itself to mount, installation of diffuse sensors is usually simpler than for through-beams and retros.

Deviations of sensing distances and false triggers when reflective backgrounds are present led to the development of other **diffuse sensors.** These new developments, allow the diffuse sensor to "see " an object while simultaneously ignoring any objects behind it.In the simplest of terms, the sensor is looking out at specific point in the foreground and ignoring anything beyond that point. There are two ways in which this function is achieved, the first and most common is using **fixed-field technology.** In this technology, the emitter sends out a beam of light like a standard diffuse photoelectric sensor. In turn, the light is received by two receivers and a comparator then evaluates how the light is received. One receiver is focused on the "sweet spot " or desired sensing location and the other on the background or long range. If the comparator finds the long-range receiver is detecting a higher intensity of reflected light, than the amount on the focused receiver, the output will not turn on. Only when the intensity of light on the focused receiver is above the long-range receiver will an output occur.

Adjustable sensing distance versions are also available. The receiver element in an adjustable-field sensor is accomplished by the use of an array of receivers and a potentiometer to electrically adjust the sensing distance.

Fixed-field and adjustable-field photoelectric sensors operate optimally at their preset "sweet spot ". They allow for the recognition of small parts and a tight drop-off between the sensed target and cutoff point. They also offer an improvement over a standard diffuse sensors ' difficulty in sensing different color targets. However, target material surface qualities, such a high gloss, can produce various results. In addition, highly reflective objects outside of the sensing area tend to send enough light intensity back to the receivers for the output to trigger, especially when the receivers are electrically adjusted.

To combat these limitations, a technology known commonly as true **background suppression by triangulation** was developed. True background suppression sensors emit a beam of light exactly like a standard diffuse, but unlike fixed-field sensors, which rely on light intensity, background suppression units rely completely on the angle at which the beam returns to the sensor.

To accomplish this, background suppression sensors employ two or more receivers accompanied by a focusing lens. The receivers remain in a fixed position, while the lens is mechanically adjusted to change the angle of received light. .This configuration allows for an extremely steep cutoff between target and background, sometimes as small as .1 mm. Also, this is a more stable method when reflective backgrounds are present, or large target color variations are an issue: reflectivity and color affect the intensity of reflected light, not the angles of refraction used by triangulation-based background suppression photos.

Photoelectric Sensor

Photoelectric sensors represent perhaps the largest variety of problem solving choices in the industrial sensor market. Today 's photoelectric technology has advanced to the point where it is common to find a sensor that will detect a target less than 1 mm in diameter while other units have a sensing range up to 60 m. These factors make them extremely adaptable in an endless array of applications. Although many configurations are available including laser-based and fiber optic sensors, all photoelectric sensors consist of a few of basic components. Each contains an emitter, which is a light source such as an LED (light emitting diode) or laser diode, a photodiode or phototransistor receiver to detect the light source, as well as the supporting electronics designed to amplify the signal relayed from the receiver.

Probably the easiest way to describe the photoelectric operating principal is: the emitter, also referred to as the sender, transmits a beam of light either visible or infrared, which in some fashion is directed to and detected by the receiver. Although many housings and designs are available they all seem to default to the basic operating principal.

Just as the basic operating principal is the same for all photoelectric families, so is identifying their output. **"Dark-On" and ""Light-On"** refers to output of the sensor in relation to when the light source is hitting the receiver. If an output is present while no light is received, this would be called a "Dark On " output. In reverse, if the output is ON while the receiver is detecting the light from the emitter, the sensor would have a "Light-On " output. Either way, a Light On or Dark On output needs to be selected prior to purchasing the sensor unless it is user adjustable. In this case it can be decided upon during installation by either flipping a switch or wiring the sensor accordingly.

The method in which light is emitted and delivered to the receiver is the way to categorize the different photoelectric configurations. The most reliable style of photoelectric sensing is the **through beam sensor**. This technology separates the emitter and receiver into separate housings. The emitter provides a constant beam of light to the receiver and detection occurs when an object passing between the two breaks the beam. Even though it is usually the most reliable, it often is the least popular due to installation difficulties and cost. This is because two separate pieces (the emitter and receiver) must be purchased, wired and installed. Difficulties often arise in the installation and alignment of two pieces in two opposing locations, which may be quite a distance apart.

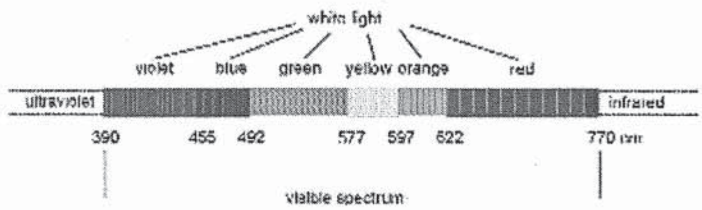
Through beam photoelectric sensors typically offer the longest sensing distance of photoelectric sensors. For example, units are available with a 25 m and more sensing range. Long range is especially common on newly developed photoelectric sensors such as models containing a laser diode as the emitter. Laser diodes are used to increase sensing accuracy and detect smaller objects These units are capable of transmitting a well-collimated beam with little diffusion over the sensing ranges as long as 60 m. Even over these long distances, some through beam laser sensors are capable of detecting an object 3 mm in diameter, while objects as small as .01 mm can be sensed at closer ranges. However, while precision increases with laser sensors the speed of response for laser and non-laser through beam sensors typically remain the same, around 500 Hz. An added bonus to through beam photoelectric sensors is their ability to effectively sense an object in the presence of a reasonable amount of airborne contaminants such as dirt. Yet if contaminants start to build up directly on the emitter or receiver, the sensor does exhibit a higher probability of false triggering. To prevent false triggering from build up on the sensor face, some manufacturers incorporate an **alarm output** into the sensor 's circuitry. This feature monitors the amount of light arriving on the receiver. If the amount light decreases to a certain level without a target in place, the sensor sends a warning out by means of a built in LED and/or an output wire.

A very familiar application of a through beam photoelectric sensor can be found is right in your home. Quite often, a garage door opener has a through beam photoelectric sensor mounted near the floor, across the width of the door. This sensor is making sure nothing is in the path of the door when it is closing. A more industrial application for a through beam photoelectric is detecting objects on a conveyor. An object will be detected anyplace on a conveyor running between the emitter and receiver as long as there is a gap between the objects and the sensors light does not "burn through " the object. This is more a figurative term than literal. It refers to an object that is thin or light in color and allows.

Basic theory

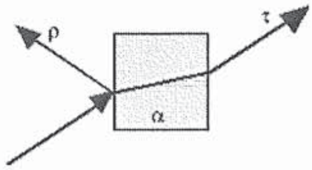
LIGHT

Visible light is an electromagnetic radiation with a wavelength between 390 and 770 nm. White light is composed of all the visible spectrum components in equal quantity; the predominance of a specific wavelength determines the colour of the light. Light Emitting Diode (LED) is the most used in optoelectronics. LEDs for all the emission colours and for white light are available today; as well as for the invisible infrared (over 770 nm) and ultraviolet (under 390 nm) radiations.



Transmission, Absorption, Reflexion

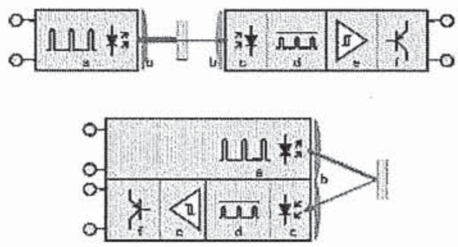
When light hits an object three phenomenons take place contemporarily: Reflection (ρ), Absorption (α), Transmission (τ); with parameters and ratios that vary according to objects, differentiated by material, surface, thickness or colour, and that can be consequently detected using a photoelectric sensor.



PHOTOELECTRIC SENSORS

A photoelectric sensor (also denominated optoelectronic sensor or more simply photocell) consists basically in the following elements:

a) a photo-emitter converts a modulated electric signal into luminous energy pulses, that can be distinguished from other light sources;
b) an optic system connects the emitter and the receiver by means of a light beam; whose variations are elaborated to detect the objects
c) a photo-receiver converts the received luminous energy into an electronic signal;
d) a demodulator-amplifier extracts and amplifies the part of the signal originated by the modulated light emitter;
e) a comparator compares the received signal with a switching threshold
f) a transistor or relay power output drives an external actuator or directly the load.



UNIVERSAL PHOTOELECTRIC SENSORS

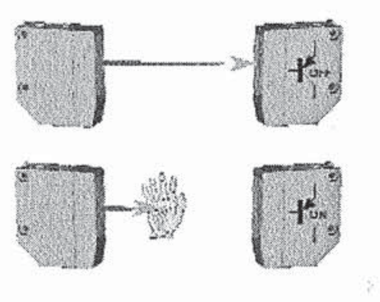
'***Universal sensors***' include all sensors with basic optic functions that can be used for common object detection, in very vast and differentiated applications. The basic optic functions are through beam, retroreflex and proximity. The various series of universal sensors differ principally for housing shape and dimensions, which condition the performances such as operating distances.

*Please refer to **S2, S3, S5, S6, S10, S12M, S18, S20, S30, S40, S41, S50, S51, S60, S7, S80, S90, SDS10, SDS5, SL5, SM, TED** series.*

Through beam

In these photoelectric sensors, the light emitter and receiver are contained in two different housings, that are mounted one in front of the other. The light beam emitted by the emitter directly hits the receiver; each object that interrupts the beam is thus detected. This system is used to obtain large signal differences (when the light directly hits the receiver and when the object interrupts the beam) with the highest Excess Gain and the largest operating distance reaching up to 50 m. Moreover, these sensors can operate in the harshest environmental conditions, such as in presence of dirt or dust. The disadvantage consists mainly in having to wire two different emitter and receiver units. The through beam optic function operates typically in the dark mode: the output is activated when the object interrupts the beam between the emitter and receiver.

Please refer to models with the following optic function codes: _F_ for receiver and _G_ for emitter.



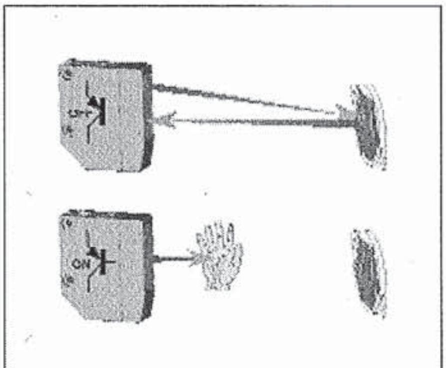
Through beam retroreflex in the DARK operating mode

Basic theory

Retroreflex

Photoelectric sensors with this optic function present both the emitter and receiver inside the same housing. The emitted light beam is reflected on the receiver thanks to a prismatic reflector; an object is thus detected when it interrupts the beam. With respect to the through beam optic function, the signal difference is reduced (when the light is freely reflected by the reflector and when an object interrupts the beam) so the Excess Gain is reduced and the maximum operating distance reaches 12 meters. Moreover it is necessary to operate in clean environments without dirt or dust. A retroreflex sensor typically operates in the dark mode: the output is activated when an object interrupts the light beam between the sensor and reflector.

*Please refer to models with the **_A_** optic function code.*

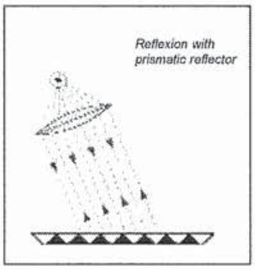


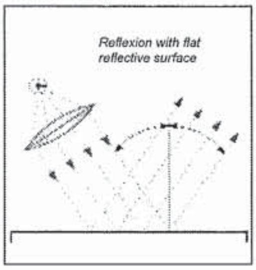
Retroreflex in the DARK operating mode

Prismatic reflector

The prismatic reflector is able to reflect the incident light in a parallel manner, with a reflection coefficient higher than any other object for angles inferior to 15°. Typically the operating distance proportionally increases according to the reflector's dimensions. The reflector can rotate the incident light's polarisation plane at 90°.

*Please refer to **R** series reflectors.*

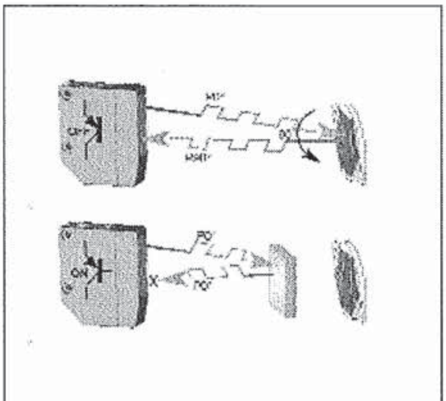




Polarised retroreflex

In presence of critical detection of objects with very reflective surfaces, such as shiny metals or mirrored glass, retroreflex sensors with polarised filters have to be used. In the polarised retroreflex sensors, the emission light is polarised on a vertical plane, while the reception is obtained only through a polarised filter on a horizontal plane. The prismatic reflector rotates the light plane at a right angle, while the light reflected from the object maintains the polarisation plane unvaried and is blocked by the filter placed on the receiver. Consequently, only the light reflected by the prismatic reflector is received.

*Please refer to models with the **_B_** optic function code.*

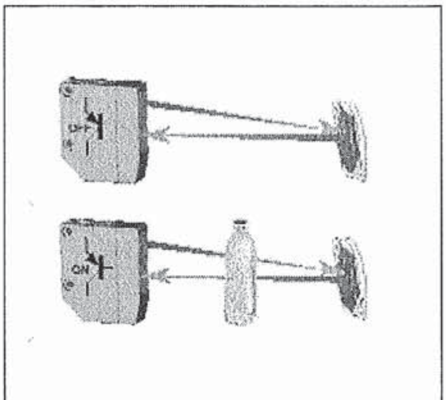


Polarised retroreflex in the DARK operating mode

Retroreflex for transparents

For the detection of transparent objects, such as PET bottles or Mylar sheets, a particular low-hysteresis retroreflex version (capable of detecting small signal differences) can be used. These sensors elaborate the very small signal difference that the light undergoes when it passes through the transparent object.

*Please refer to models with the **_T_** optic function code.*



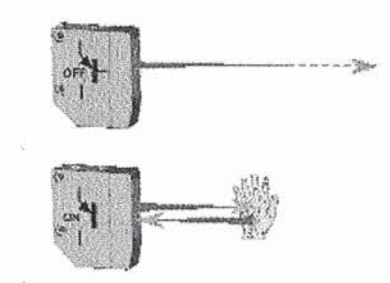
Retroreflex for transparents in the DARK operating mode

Diffuse proximity

Photoelectric sensors with this optic function present both the emitter and receiver inside the same housing. The light beam emitted is reflected on to the receiver directly by the object, which is detected without the need of prismatic reflectors. The proximity sensors represent the most economic and fastest mounting solution. However, they work with weaker signals compared to the retroreflex sensors and so the Excess Gain is reduced and the operating distance, depending on the object's reflection degree, reaches 2 meters.

A proximity sensor normally operates in a light mode: the output is activated when an object enters the detection area and reflects the light emitted by the sensor.

*Please refer to models with the following optic function codes: _**C**_ (long distance) and _**K**_ (short distance).*

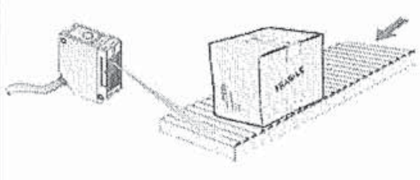


Diffuse proximity in the LIGHT operating mode

Fixed focus proximity

The fixed focus proximity sensor offers a simple fixed background suppression distance beyond which no object is detected. The fixed triangulation of the optics greatly reduces the detection distance of reflective objects. The visible red emission facilitates sensor installation.

*Please refer to models with the _**D**_ optic function code.*

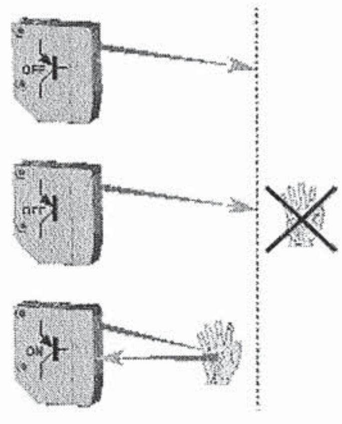


Fixed focus proximity in the LIGHT operating mode

Background suppression proximity

The background proximity function allows the operator to precisely fix the maximum detection distance. The operating distance adjustment is not based upon the receiver's sensitivity, but is obtained through optic triangulation, mechanically acting on the lenses or photoelements angle or electronically using PSD (Position-Sensitive Detectors) receiving systems. Consequently the detection of an object is independent of other objects lying behind (or in the background), which are suppressed. Moreover, thanks to this adjustment method, all objects can be detected almost at the same distance independent of their colour.

*Please refer to models with the _**M**_ optic function code.*



Background suppression proximity in the LIGHT operating mode

Basic theory

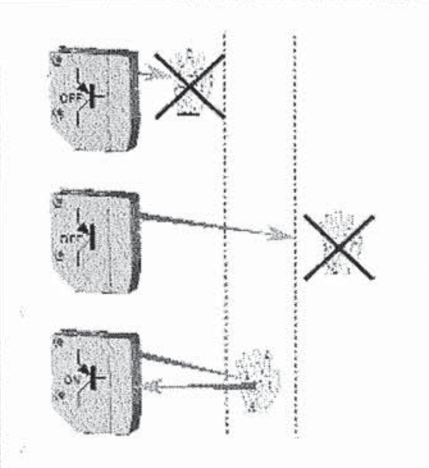
Foreground-background suppression proximity

The foreground-background proximity function allows the operator to precisely fix the minimum and the maximum detection distance. Consequently an object is detected only inside a given area, avoiding the interference of objects lying before (foreground) or behind (background), which are suppressed.

With this function it is possible to suppress the detection of a box edges and bottom, detecting only the eventual presence of contained goods.

Otherwise it is possible to set the sensor for a conveyor's plane detection, using the normally closed output to detect the objects lying in the foreground, without any risk of false commutation even in presence of very reflective and corrugated surfaces.

*Please refer to models with the **_N_** optic function code.*



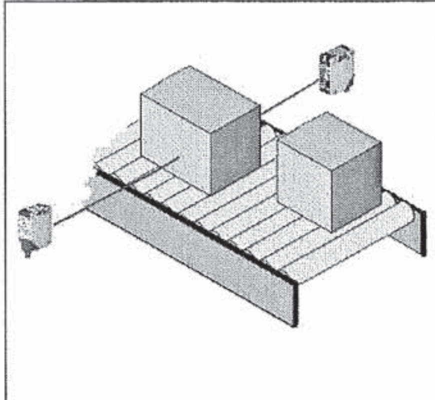
Foreground-background suppression proximity in the LIGHT operating mode

Distance sensors

Distance sensors supply an analogue signal on a 0-10V or 4-20mA output proportional to the measurement of the distance between the emitting optics and the target.

The main technologies that lie at the basis are optic triangulation and time of flight. The first suits very precise measurements on short distances, while the second is ideal for medium and long distances.

Please refer to models with the _Y_ optic function code.



Time of flight technology (T.O.F.)

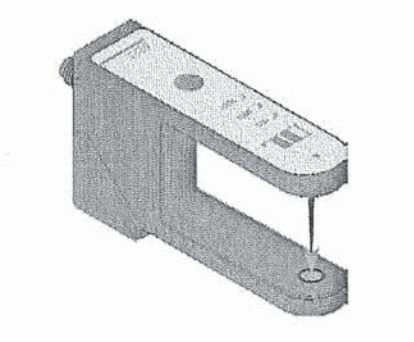
APPLICATION PHOTOELECTRIC SENSORS

'Application' sensors are photocells that, due to technical particulars or optic function specialisation, can be used only in some specific applications.

Slot sensors

A slot sensor is a particular version of the through beam retroreflex sensor, where the emitter and receiver are placed opposite each other on the internal sides of an U-shaped housing. Any target that passes through the internal slot interrupts the beam and is detected. Due to the particular construction, slot sensors are limited to applications with operating distances of some centimeters. The most typical slot sensor applications are hole or teeth detection on wheels, label detection on thin supports, or the control of edge and continuity of sheets or tapes. The emission is generally infrared light; however visible red or green emission versions are available, able to detect references such as registration marks, that present colour contrasts on translucid films.

*Please refer to **SR21, SR31, SRF** slot sensor series.*



Slot sensor

Contrast sensors

Contrast sensors (also defined colour mark readers, according to the most popular application) present a proximity function but, instead of detecting only the presence or absence of an object, they are able to distinguish two surfaces according to the contrast produced by the different reflection degree. In this manner a dark reference mark (low reflection) can be detected thanks to the contrast with a lighter surface (high reflection), or viceversa. In presence of coloured surfaces, the contrast is highlighted using a LED with coloured light emission, typically a selectable red or green LED.

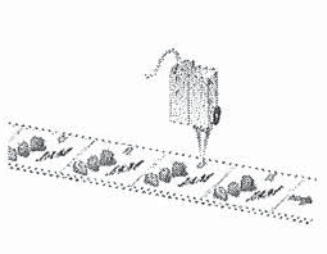
MARK COLOUR	*Red LED*	*Green LED*	*White LED*
Red	no	medium	medium
Orange	low	medium	medium
Yellow	low	low	medium
Green	high	no	medium
Blue	high	medium	high
Violet	medium	high	high
Brown	low	medium	high
Black	high	high	high
Grey	medium	medium	medium
White	no	no	possible

Contrast obtainable on white background

For general purposes a white light emission is used, which thanks to the full spectrum detects the majority of contrasts. The white light emission is obtained through lamps, or LEDs in the most recent sensors, enabling the detection of very slight contrasts due to different surface treatments, even of the same material and colour.

The contrast sensors are mainly used in automatic packaging machines for register mark detection to synchronise all the folding, cutting and welding phases.

*Please refer to **TL10, TL80, TLμ, S50, S60, S65, S90** contrast sensor series with the _W_ optic function code.*

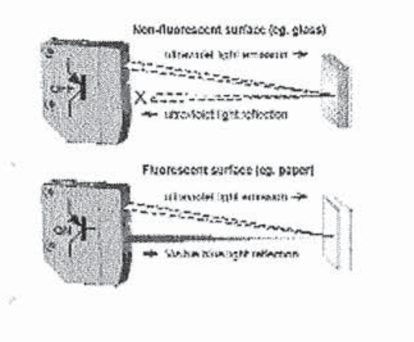


Contrast sensor

Luminescence sensors

'Luminescence' is defined as the visible light emission on the behalf of fluorescent or phosphorous substances, due to electromagnetic radiation absorption. Luminescence sensors emit ultraviolet light, which is reflected at a higher wavelength (minor energy) on the fluorescent surface, shifting into the visible light spectrum. The ultraviolet light emission is obtained using special lamps, or LEDs in the more recent sensors. The U.V. emission is modulated and the visible light reception is synchronised. The maximum immunity against external interferences, such as reflections caused by very shiny surfaces, is consequently obtained and fluorescent targets, invisible to the human eye, can be detected. Luminescence sensors are used in various industrial fields: pharmaceutical and cosmetic to detect labels on glass or mirrors; ceramic to select tiles marked with fluorescent signs; automatic packaging to detect paper of fluorescent glues; textile to distinguish cutting and sewing guides; mechanical to check fluorescent paints or lubricants.

*Please refer to **LDμ** luminescence sensors series.*

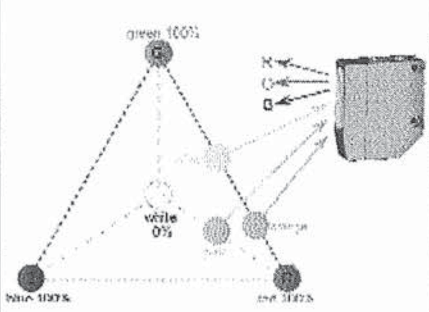


Luminescence sensor

Colour sensors

The colour of an illuminated object depends on all the colour components of the incident light which are reflected, eliminating those which are instead absorbed. The dominant colour is defined 'hue' and depends on the reflected light's wavelength; while the 'saturation' indicates the pureness percentage with respect to white that represents 0%. The hue and saturation are together defined 'chromaticity' or 'chromatism'. Colour or chromatic sensors have a proximity function with generally a triple RGB LEDs light emission. The colour of an object is identified according to the different reflection coefficients obtained with the red (R), green (G) and blue (B) light emissions. More simply, yellow can be identified by R=50% G=50% B=0% reflections; orange by R=75% G=25% B=0% reflections; pink by R=50% G=0% B=0% reflections; but the combinations are practically infinite. Colour sensors operate only on reflection ratios and are not influenced by light intensity, defined instead 'brilliance 'or 'luminance'. The applications are extremely common in all fields, ranging from quality and process controls, or automatic materials handling for the identification, orientation and selection of objects according to the colour.

*Please refer to the **S65-V**, **TEC** colour sensor series.*

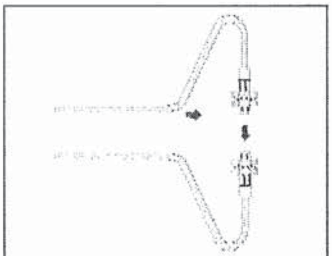


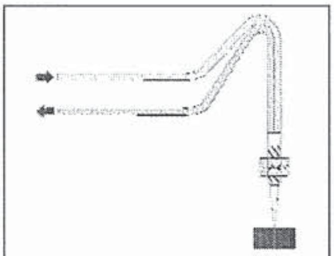
Colour sensor

Fibre optic sensors

All the universal optic functions of through-beam and proximity, as well as the application functions ranging from contrast and luminescence to colour detection, can be obtained using fibre optic sensors. The optic fibres can be considered as cables that transport light and can be used to dislocate the sensor's optics in small spaces, or to detect very small objects. An optic fibre is composed of a cylindrical glass or plastic core, surrounded by a Teflon or Silicon cladder. The difference between the core and the cladder refraction indexes allows the light to be diffused inside the fibre in a guided manner. The cladding is covered by a plastic or metal sheath, which has an exclusively mechanical protection function. The fibres with a glass core and metal sheath are suitable for very high temperature uses, or for particular mechanical requirements. The plastic fibres, offering great adaptability, are the most diffused in all applications. The plastic optic fibres have a standard 2.2 mm external diameter and generally end with a cylindrical threaded metal head, useful for mechanical mounting. The fibre lengths reach commonly 1 and 2 meters; performance reductions become significant with lengths over 5 meters. Plastic optic fibres can be shortened using a special fibre-cutting tool, to be used only for limited times; cutting the fibre with a non-sharp or non-perpendicular blade will produce a consistent reduction of the operating distance. High temperature, extra-flexible or high efficiency versions are present amongst plastic optic fibres range.

*Please refer to **OF** series fibre optics; **S3**, **S5**, **S7** universal sensor series with _E_ optic function; **TED**, **TL80**, **TLμ** contrast sensor series; **LDμ** luminescence sensor series; **TEC** colour sensor series.*


Through beam fibres


Proximity fibres

LASER sensors

A LASER (Light Amplification by Stimulated Emission of Radiation) is an electronic device, such as a diode, that converts energy source into a very thin and concentrated light beam, suitable to detect very small objects or to reach very high operating distances. With reference to the safety of the laser radiation, according to the EN 60825-1 European standard, class 1 requires that the laser device is safe under reasonably foreseeable conditions of operations, not being dangerous for people in any situation; while class 2 states that the eye is normally protection afforded by aversion responses including the blink reflex, thus precautions must be adopted to avoid staring into beam.

Please refer to ***S40, S50, S60, S80, S90, SL5,*** *sensor series with LASER emission.*

REFERENCE STANDARDS

All Datasensor SpA products with CE marking comply with the European Directives relative to Electromagnetic Compatibility (EEC 89/336 and successive 92/31 and 93/68) and Low Voltage (LVD 73/23 and successive 93/68) and corresponding European standards for industrial environment use.

Photoelectric sensors refer to the EN 60947 European standard for Low Voltage Switchgear and Controlgear; Part 1: General rule; Part 5: Control Devices and Switching Elements, Section 2: Proximity Switches.

Note: these photoelectric sensors are not suitable as safety components according to the 89/392/EEC machinery directive and successive 91/368/EEC and 93/44/EEC amendments; please refer to light beam devices under the 'Safety Devices' section.

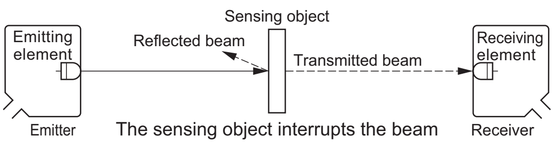
PHOTOELECTRIC SENSORS

INTRODUCTION

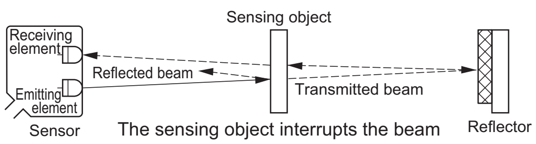
Principles of operation

- Photoelectric sensor is a generic name for sensors which detect an object by using light. The optical signal transmitted from the emitting part of the sensor is modified by being reflected, transmitted, absorbed, etc., by the sensing object and is then detected by the receiving part of the sensor to generate a corresponding output signal. Further, it can also be a sensor which detects light radiated from the sensing object to generate an output signal.

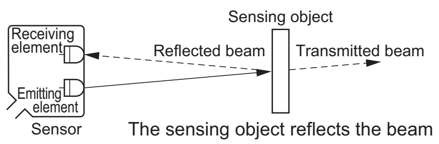
Thru-beam type



Retroreflective type



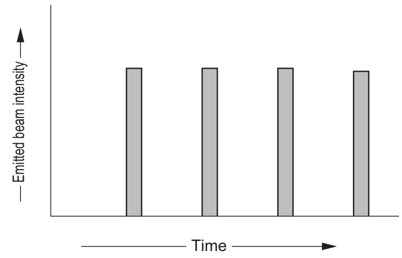
Reflective type



Emitting method

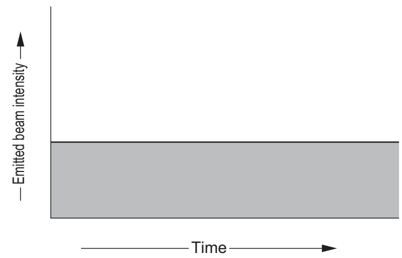
Pulse-modulated

- Most of the photoelectric sensors emit a beam which is pulse-modulated.
  In this method, a strong optical signal of fixed width is emitted at a fixed time interval.
  This helps the receiver to distinguish the signal from extraneous light and to achieve a long sensing range.



Unmodulated

- The high-speed fiber sensor **FX2-A3R** and the micro photoelectric sensor **PM** series use an unmodulated beam.
  In this method, the beam is emitted constantly at a fixed intensity.
  This enables high-speed response, although the sensors are a little susceptible to extraneous light as compared to the sensors using a modulated beam.



FEATURES

Non-contact detection

- Detects an object without contact.
  Non-contact sensing ensures longer life for the sensor and absolutely no damage to the object.

Long sensing range

- The thru-beam type with a maximum sensing range of 50 m 164.042 ft (**RX-M50**), and the diffuse reflective type with a maximum sensing range of 5 m 16.404 ft (**PX-26**) are available.
  The long sensing range make the sensors suitable for a variety of applications.

Various objects detectable

- The sensors can detect objects of any material provided they affect the optical beam.

High-speed response

- The use of an optical beam for detection and complete electronic circuitry makes the sensors respond so quickly that they can be easily used on a high-speed production line.

Color identification

- This is a special feature of photoelectric sensors, which use light for detection.
  Since the reflection and the absorption characteristics vary with the object color for a specified incident optical wavelength, various colors can be detected as the difference in optical intensity.

High accuracy detection

- Advanced optical system and electronic circuit technology have achieved a sensing accuracy of up to 20 μm 0.787 mil (**SH-82R**).

※ Photoelectric sensors have the drawback that if the lens surface is covered with dust or dirt and light transmission is obstructed, detection may not be possible.

TYPES OF SENSORS

Classification methods

• There are various types of photoelectric sensors. Four different methods of classification, depending on the objective considered, are explained here.

① Classification by structure

This classification is based on the manner in which the circuit configuration elements are built-in or separated. This classification is useful to select sensors in view of the mounting space, power supply and noise immunity.

- Photoelectric sensor
  - Amplifier built-in
  - Power supply built-in
  - Amplifier-separated
  - Fiber type

② Classification by sensing mode

This classification is based on how the light is emitted and received and on the sensor shape. This classification is useful to select sensors in view of the sensing object size and the surrounding conditions.

- Photoelectric sensor
  - Thru-beam type
    - General purpose
    - U-shaped
    - Area
  - Retroreflective type
    - General purpose
    - With polarizing filters
    - Transparent object detection
  - Reflective type
    - Diffuse reflective
    - Narrow-view reflective
    - Convergent reflective
    - Adjustable range & fixed focus
    - Mark sensing

③ Classification by beam source

This classification is based on the type of beam source used.
This classification is useful to select sensors in view of the sensing distance and the color differences of objects.

- Photoelectric sensor
  - Infrared beam
  - Red beam
  - Green beam
  - Blue beam
  - Three color beam (Red • Green • Blue)

④ Classification by output circuit

This classification is based on the type of output circuit and the output voltage.
This classification is useful to select sensors according to the input conditions of the device or equipment connected to the sensor output.

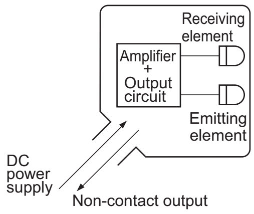
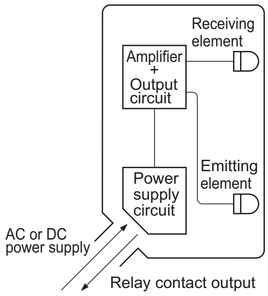
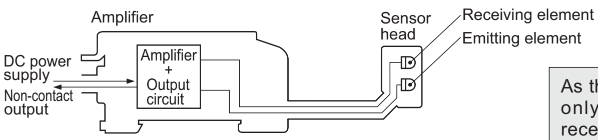
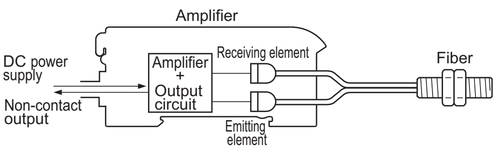
- Photoelectric sensor
  - Non-contact
    - DC 2-wire
    - NPN open-collector transistor
    - PNP open-collector transistor
    - NPN transistor universal
    - AC non-contact (Thyristor)
    - Analog voltage
  - With contact
    - Relay contact

PHOTOELECTRIC SENSORS

TYPES OF SENSORS

Classification

① Classification by structure

Type	Outline and Features
Amplifier built-in	 Since the amplifier is built-in, just connecting the DC power supply can provide a relay drive output.
Power supply built-in	 Since all necessary functions of a photoelectric sensor are incorporated, just connecting the power supply (100V / 200V AC) can provide a relay contact output.
Amplifier-separated	 As the sensor head contains only the emitting and the receiving elements, its size can be made small. Further, the sensitivity adjustment can be done from a remote place.
Fiber	 It has supreme environmental resistance, since the sensing portion (fiber) contains absolutely no electrical parts. (Refer to p.1138)

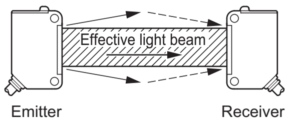
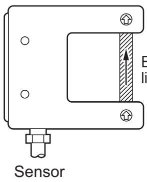
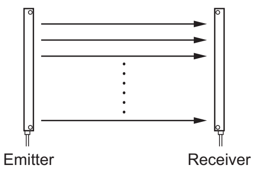
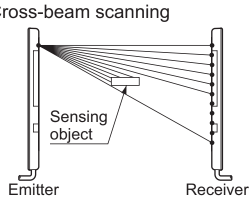
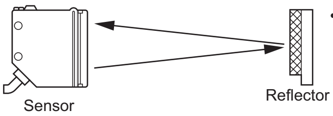
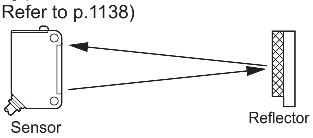
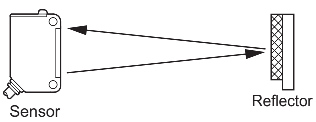
Feature comparison table

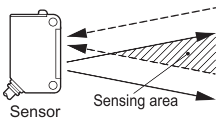
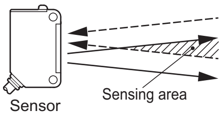
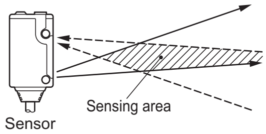
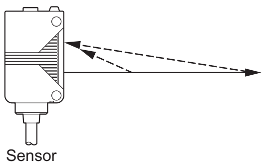
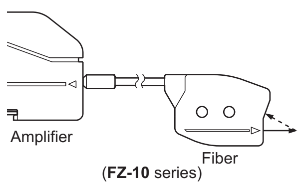
Type \ Feature	Sensor head size	Noise immunity	Lifetime	Ease of use
Amplifier built-in	○	○	◎	○
Power supply built-in	△	○	△	◎
Amplifier-separated	◎	△	◎	○
Fiber	◎	◎	◎	◎

◎: Excellent
○: Good
△: Fair

TYPES OF SENSORS

② Classification by sensing mode

Type		Outline	Features
Thru-beam	General purpose	Detects an object that interrupts the light beam traveling from the emitter to the receiver.  	• Long sensing range • Precise detection • Small object detectable • Not affected by shape, color or material of sensing objects (opaque) • Resistant to dirt and dust on the lens
Thru-beam	U-shaped	The emitter and the receiver are in one enclosure.  	• No beam alignment needed • Precise detection • Small object detectable • Not affected by shape, color or material of sensing objects (opaque) • Resistant to dirt and dust on the lens
Thru-beam	Area	Light curtain is made up of arrayed emitting and receiving elements.  ※Cross-beam scanning  	• Object is detectable as long as it is anywhere in the defined sensing area • Not affected by shape, color or material of sensing objects (opaque) • Resistant to dirt and dust on the lenses • Thin objects, such as postcards, can be detected (Cross-beam scanning type only. Refer to p.1139.)
Retroreflective	General purpose	Detects an object that has a reflectivity smaller than the reflector and interrupts the light beam traveling between the sensor and the reflector.  	• Easy beam alignment • Wiring only on one side • Space saving compared to thru-beam type sensors • Not affected by shape, color or material of sensing objects (opaque)
Retroreflective	With polarizing filters	It enables detection of even a specular object by attachment of polarizing filters to the emitting and the receiving parts. (Refer to p.1138)  	• Specular object detection • Easy beam alignment • Wiring only on one side • Space saving compared to thru-beam type sensors • Not affected by shape, color or material of sensing objects (opaque)
Retroreflective	Transparent object detection	The specially devised optical system enables detection of even a transparent object.  	• Transparent object detection • Easy beam alignment • Wiring only on one side • Space saving compared to thru-beam type sensors • Not affected by shape, color or material of sensing objects

Type		Outline	Features
Reflective	Diffuse reflective	Emits a beam onto the object and detects the object by receiving the beam reflected from the object surface.  	• No beam alignment needed • Space saving • Wiring only on one side • Object with fluctuating position detectable • Wide sensing area
Reflective	Narrow-view reflective	The sensing area is narrowed by the optical system.  	• Hardly affected by surroundings • More accurate detection compared to diffuse reflective type sensors • No beam alignment needed • Space saving • Wiring only on one side
Reflective	Convergent reflective	Detects an object in the area where the emitting and the receiving envelopes overlap. A spot-beam type sensor detects an object at just the point where these envelopes cross over.  	• Less affected by background and surroundings • Precise detection • No beam alignment needed • Space saving • Wiring only on one side
Reflective	Adjustable range & fixed-focus reflective	Emits a spot beam onto an object and senses the difference in the reflected beam angle. (Refer to p.1138)  	• Not affected by shape, color or material of sensing objects • Hardly affected by background and surroundings • Small object detectable with high accuracy • No beam alignment needed • Space saving • Wiring only on one side • Not susceptible to temperature drift and voltage fluctuation
Reflective	Mark sensing	Projects a spot-beam on the target color, and identifies the color by sensing the amount of reflected beam and the relative ratio among color components.  (**FZ-10** series)	• Color identifiable • Hardly affected by background and surroundings • Small object detectable with high accuracy • No beam alignment needed • Space saving (**FZ-10** series) • Wiring only on one side

PHOTOELECTRIC SENSORS

TYPES OF SENSORS

③ Classification by beam source

Type	Features
Infrared beam	• Intense beam offers long sensing range • Unable to expose films
Red beam	• Suitable for color mark sensing • Visible
Green beam	• Suitable for color mark sensing • Suitable for minute detection because of a high beam damping ratio. • Visible
Blue beam	• Suitable for color mark sensing • Suitable for minute detection because of a high beam damping ratio. • Visible
Three color beam (Red • Green • Blue)	• Color detected by resolving it into three color components • Fine color discrimination possible

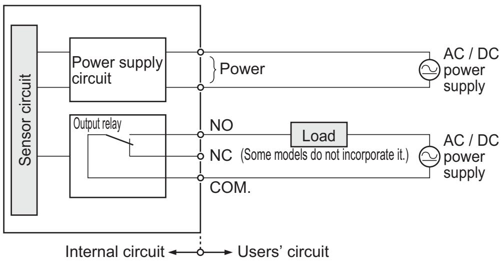
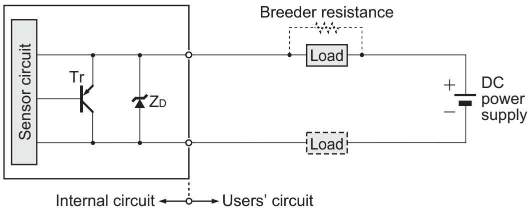
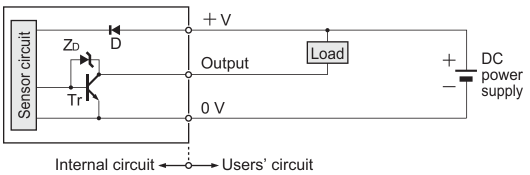
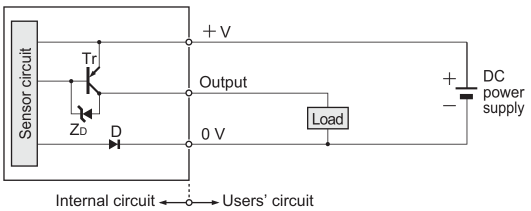
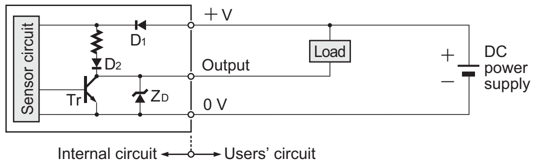
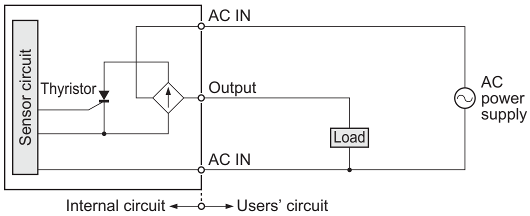
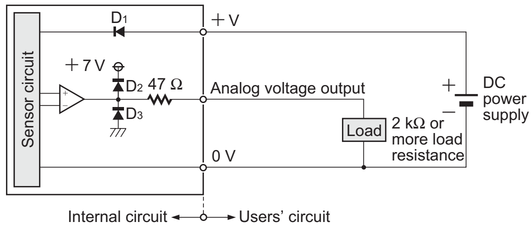
Color combinations that can be discerned during mark sensing

Background color \ Mark color	White	Yellow	Orange	Red	Green	Blue	Black
White		Ⓑ	Ⓑ	ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Yellow	Ⓑ		Ⓖ	Ⓖ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Orange	Ⓑ	Ⓖ		ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Red	ⒼⒷ	Ⓖ	ⒼⒷ		Ⓡ	ⓇⒷ	ⓇⒷ
Green	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	Ⓡ		Ⓑ	Ⓑ
Blue	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ		Ⓑ
Black	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ	Ⓑ	

Ⓡ: Red LED type Ⓖ: Green LED type Ⓑ: Blue LED type

TYPES OF SENSORS

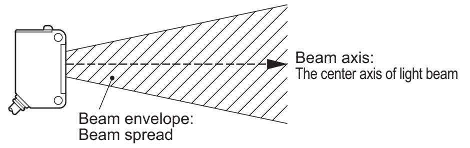
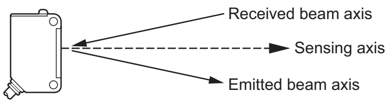
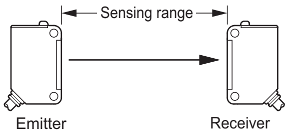
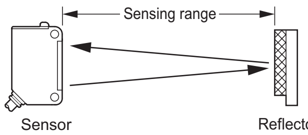
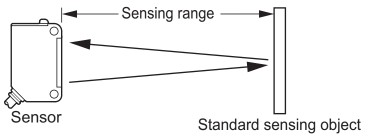
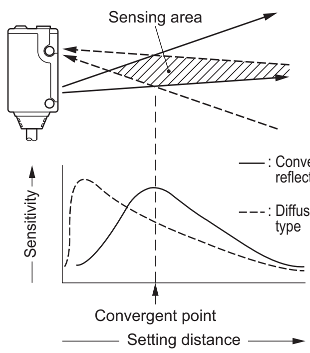
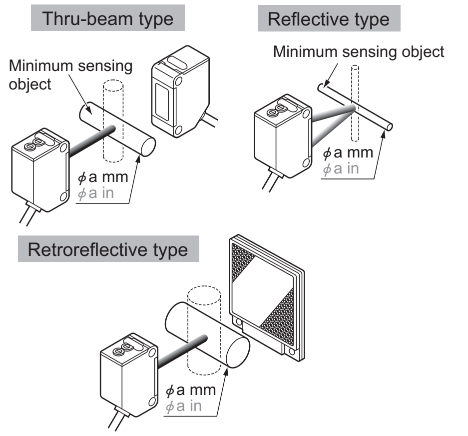
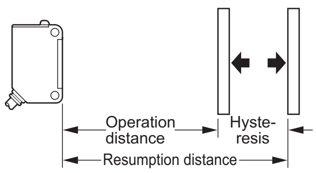
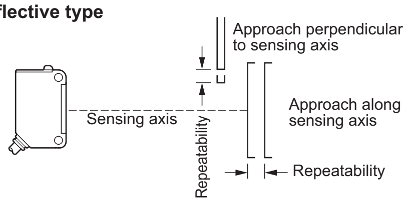
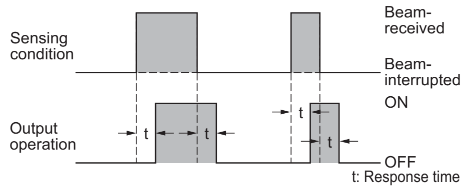
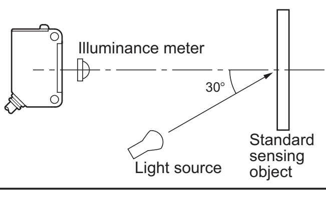
④ Classification by output circuit

Type		Outline and Features
With contact	Relay contact	• Drives AC load or DC load • Large switching capacity • Delayed response compared to non-contact output 
Non-contact	DC 2-wire	• Wire saving • Low current consumption • Semi-permanent life • High-speed response • Limitation on connectable load Symbols ... Z_D: Surge absorption zener diode Tr : PNP output transistor
	NPN open-collector transistor	• Able to drive a relay, PLC, TTL logic circuit, etc. • A separate power supply can be used for the load. • Semi-permanent life • High-speed response • Commonly used in North America or Japan Symbols ... D: Reverse supply polarity protection diode Z_D: Surge absorption zener diode (Its position differs with the model.) Tr : NPN output transistor
	PNP open-collector transistor	• Commonly used output circuit in Europe • Power supply is not required for the load. • Semi-permanent life • High-speed response Symbols ... D: Reverse supply polarity protection diode (Its position differs with model.) Z_D: Surge absorption zener diode (Its position differs with the model.) Tr : PNP output transistor
	NPN transistor universal	• Able to drive a relay, PLC and logic circuit • Semi-permanent life • A separate power supply can be used for the load. (However, its voltage must be higher than the sensor power supply.) • High-speed response Symbols ... D_1: Reverse supply polarity protection diode (Its position differs with the model.) D_2: Reverse current prevention diode (Its position differs with the model.) Z_D: Surge absorption zener diode Tr : NPN output transistor
	AC non-contact (Thyristor)	• Able to drive AC load directly • Semi-permanent life 
	Analog voltage	• Outputs an analog voltage proportional to the amount of incident beam Symbols ... D_1: Reverse supply polarity protection diode D_2, D_3: Surge absorption diode

Classification	Item	FX-301	FX-311	FX-11A	FZ-10	CX-400	EX-30	EX-20	EX-10	EQ-30	EX-40	RX	RX-LS200	CY	PX-2	RT-610	PM	PM2	NX5	VF	EQ-500	SU-7/SH	SS-A5	SF4-AH	SF2-A	SF2-N	SF2-EH	SF1-F	NA2-N	NA1-11	NA1-PK5/5	NA1-PK3	M-DW1	FT-K□	FD-L43	FD-L41	SH-72	M	HD-T1	EX-F70/F60	FD-F705	FT-F902	FX-301-F	EX-F1	FD-F4□	FD-F8Y	FT-Z8Y	FD-H30-L32, FD-H18-L31	EZ-10
Type		Fiber sensors				Photoerectric sensors																		Light curtains for safeguard				Area sensors					Sensors for semiconductor industry																
Type		Digital setting	Manually set	Analog output	Color detection	Amplifier built-in											Micro		Power supply built-in			Amplifier-separated		Light curtains for safeguard				Individual beam outputs	Slim body		Picking		Glass substrate / wafer sensing							Leak liquid / Liquid level sensing							Chemical-resistant	Heat-resistant	Water-
① Classification by structure	Amplifier built-in type					○	○	○	○	○	○	○	○	○	○	○	○	○						○	○	○	○	○ (Note 1)	○	○	○	○	○					○		○				○					○
① Classification by structure	Power supply built-in													○					○	○	○																												
① Classification by structure	Amplifier-separated type (DC power supply)																					○	○														○		○										
① Classification by structure	Fiber type	○	○	○	○																													○	○	○					○	○	○		○	○	○	○	
② Classification by sensing mode — Thru-beam	General use purpose	○	○	○		○	○	○	○			○		○					○	○		○	○											○													○		○
② Classification by sensing mode — Thru-beam	U-shaped															○	○																					○	○										
② Classification by sensing mode — Thru-beam	Area	○	○	○																				○	○	○	○	○	○	○	○	○																	
② Classification by sensing mode — Thru-beam	Others																																									○	○						
② Classification by sensing mode — Retroreflective	General use purpose							○				○		○					○	○																													
② Classification by sensing mode — Retroreflective	With polarizing filters					○						○		○					○	○																													
② Classification by sensing mode — Retroreflective	Transparent object detection											○																																					
② Classification by sensing mode — Reflective	Diffuse reflective	○	○	○		○	○	○				○		○	○				○	○		○	○																										
② Classification by sensing mode — Reflective	Narrow-view reflective					○		○																																									
② Classification by sensing mode — Reflective	Convergent reflective	○	○					○	○		○							○				○	○												○	○	○											○	
② Classification by sensing mode — Reflective	Adjustable range & fixed-focus reflective									○			○								○												○																
② Classification by sensing mode — Reflective	Mark sensing	○	○	○	○																	○																											
② Classification by sensing mode — Reflective	Others																																							○	○		○	○	○	○			
③ Classification by beam source	Infrared beam	○				○				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○			○	○		○				○			○		○
③ Classification by beam source	Red beam	○	○	○		○	○	○	○		○	○		○		○			○	○		○	○										○	○	○	○			○		○	○	○		○	○	○	○	
③ Classification by beam source	Green beam	○	○									○				○						○	○											○													○		
③ Classification by beam source	Blue beam	○	○																															○													○		
③ Classification by beam source	Three color beam (Red • Green • Blue)				○																																												
④ Classification by output circuit	Relay contact																		○	○	○																												
④ Classification by output circuit	DC 2-wire											○																																					
④ Classification by output circuit	NPN open-collector transistor	○	○		○	○	○	○	○	○	○	○	○	○	○		○	○				○	○	○	○	○	○	○ (Note 1)	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○
④ Classification by output circuit	PNP open-collector transistor	○	○		○	○	○	○	○	○			○	○			○					○		○	○	○	○		○	○	○	○	○	○	○	○	○				○	○	○		○	○	○	○	○
④ Classification by output circuit	NPN transistor universal															○																																	
④ Classification by output circuit	AC non-contact (Thyristor)													○																																			
④ Classification by output circuit	Analog voltage			○																																			○ (Note 2)										

PHOTOELECTRIC SENSORS

GLOSSARY

Term	Description
Beam envelope Beam axis	
Sensing axis	The center axis between the emitted beam axis and the received beam axis. For the thru-beam type sensor, it is identical to the beam axis. 
Sensing range Distance to convergent point	• **Thru-beam type** The distance which can be set between the emitter and the receiver under the stable sensing condition. (The abbreviation '0～' is set for values starting from 0.)  • **Retroreflective type** The distance which can be set between the sensor and the reflector under the stable sensing condition. (The abbreviation '0～' is set for values starting from 0.)  • **Reflective type** The distance which can be set between the sensor and the standard sensing object (normally, white non-glossy paper) under the stable sensing condition. (The abbreviation '0～' is set for values starting from 0.)  ※ Distance to convergent point: With the convergent reflective type sensor or the mark sensor, sensitivity is not proportional to the setting distance and the maximum sensitivity point is at an intermediate position. This point at which the sensitivity is maximum is called the convergent point and is specified along with the sensing range. 
Standard sensing object	The standard sensing object for determining the basic specifications of reflective type sensors. Normally, it is white non-glossy paper, but some particular sensors use other objects to suit the application. (e.g., glass)
Minimum sensing object	The minimum object size that the sensor can detect under the specified conditions. In the thru-beam type and the retroreflective type, the size of an opaque object is specified. In the diffuse reflective type, the diameter of a gold wire or a copper wire is specified. (ϕxxx mm ϕxxx in value is expressed) 
Hysteresis	For a reflective type sensor, the hysteresis is the difference between the operation distance, when the output first turns ON with the standard sensing object approaching along the sensing axis, and the resumption distance, when the output first turns OFF with the standard sensing object receding. 
Repeatability	The difference in the operating position when operation is repeated under constant conditions. • **Reflective type** 
Response time	The time lag between a change in the sensing state and the turning ON / OFF of the sensing output. 
Ambient illuminance	The maximum ambient light intensity that does not cause sensor malfunction. It is expressed as the permissible light intensity at the light receiving face. 

GLOSSARY

Term	Description
Protection	See below

Protection

Degree of protection against water, human body and solid foreign material.
Protection degree is specified as per IEC (International Electrotechnical Commission).

• IEC standard

IP□□

Second figure . . . Protection against water penetration
First figure . . . . . . Protection against human body and solid foreign material

• Protection degree specified by the first figure

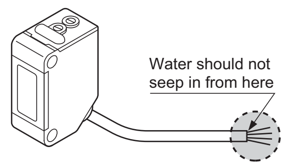
First figure	Description
0	No protection
1	Protection against contact with internal live parts by a human hand (ϕ50 mm ϕ1.969 in)
2	Protection against contact with internal live parts by a human finger (ϕ12 mm ϕ0.472 in)
3	Protection against contact with internal live parts by a solid object more than 2.5 mm 0.098 in in thickness or diameter
4	Protection against contact with internal live parts by a solid object more than 1.0 mm 0.039 in in thickness or diameter
5	Protection against dust penetration which can affect operation
6	Complete protection against dust penetration

Note: The IEC standard prescribes test procedures for each protection degree given above. The protection degree specified in the product specifications has been decided according to these tests.

• Protection degree specified by the second figure

Second figure	Description
0	No protection
1	No harmful effect due to vertically falling water drops
2	No harmful effect due to water drops falling from a range 15° wider than the vertical
3	No harmful effect due to water drops falling from a range 60° wider than the vertical
4	No harmful effect due to water splashes from any direction
5	No harmful effect due to direct water jet from any direction
6	No water penetration due to direct water jet from any direction
7	No water penetration due to immersion in water under specified conditions
8	Usable during immersion in water at the specified pressure

Caution
Although the protection degree is specified for the sensor including the cable, the cable end is not waterproof, and is not covered by the protection specified. Hence, make sure that water does not seep in from the cable end.



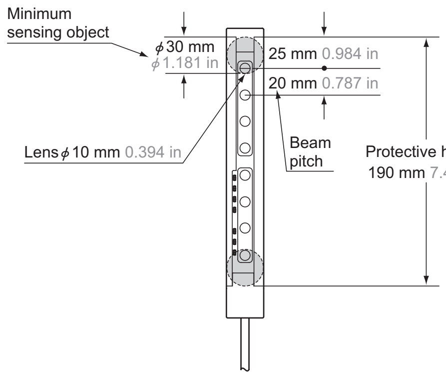
• JEM standards (Standards of the Japan Electrical Manufacturer's association)
IP67g
This specifies protection against oil in addition to IP67 protection of IEC standards. It specifies that oil drops or bubbles should not enter from any direction.

Sensing height (Protective height)

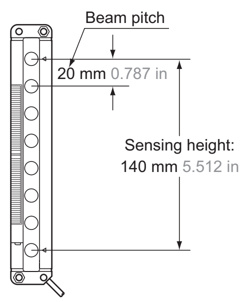
This represents the range within which sensing objects can be detected for the light curtain and area sensor. The conventional light curtain (**SF2-EH** series) and area sensor has a sensing height (protective height) limited to the height from the bottommost end beam axis to the topmost end beam axis.

20 mm 0.787 in beam pitch

<**SF4-AH** series>



<Conventional model>



PHOTOELECTRIC SENSORS

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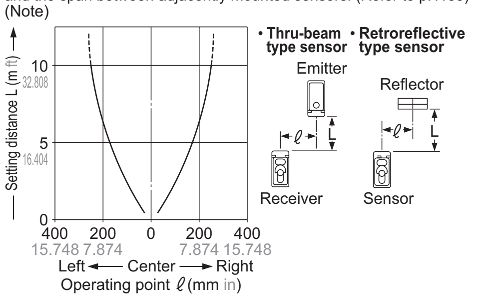
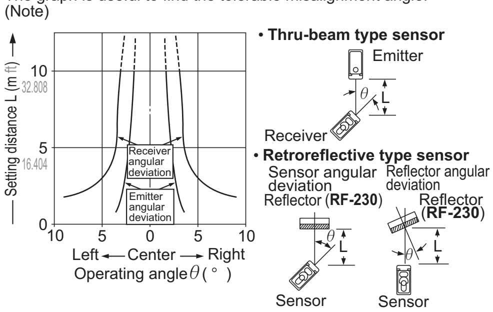
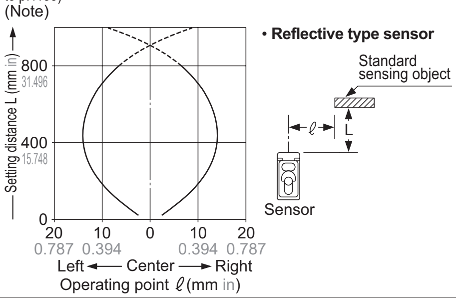
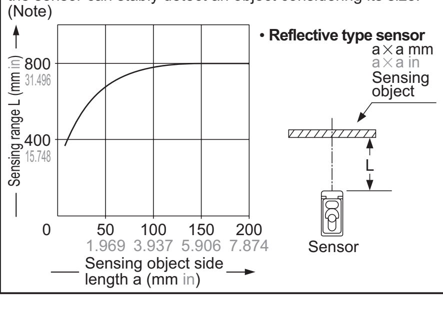
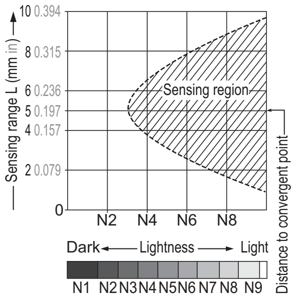
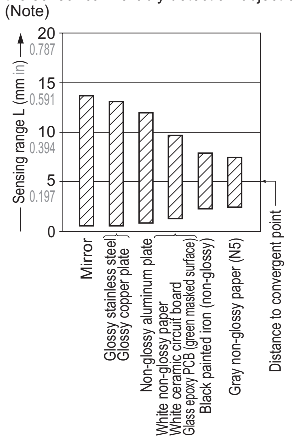
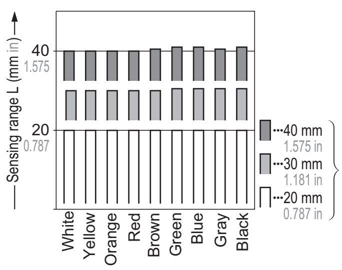
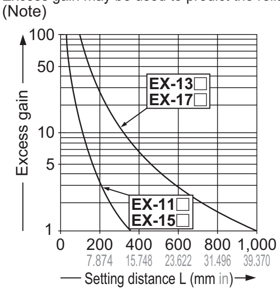
<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>Parallel deviation</td><td>The parallel deviation diagram of the thru-beam type and the retroreflective type sensors represents the boundary within which the receiver will effectively see the emitted light beam. The curves are plotted as a series of operating points at which the sensor enters the beam received condition when the emitter or the reflector moves from the left or the right towards the receiver at different setting distances (with the sensitivity adjuster at maximum sensitivity).
The graph is useful to determine the tolerance on beam alignment and the span between adjacently mounted sensors. (Refer to p.1135)
(Note)

</td></tr>
<tr><td>Angular deviation</td><td>The angular deviation diagram of the thru-beam type and the retroreflective type sensors represents the angular range within which the receiver will effectively see the emitted light beam.
The curves are plotted as a series of points representing the angle at which the sensor enters the beam received condition as the angle is gradually reduced by moving the sensor or the reflector towards the center axis from the left or the right at different setting distances (with the sensitivity adjuster at maximum sensitivity).
The graph is useful to find the tolerable misalignment angle.
(Note)

</td></tr>
<tr><td>Sensing field</td><td>The sensing field diagram of the diffuse or the convergent reflective type sensor represents the boundary within which the sensor will be operated by the reflected beam from the standard sensing object.
The curves are plotted as a series of operating points at which the sensor enters the beam received state when the standard sensing object approaches from the left or the right for different setting distances (with the sensitivity adjuster at maximum sensitivity).
The graph is useful to determine the mounting position of the sensor with respect to the sensing object and the span between adjacently mounted sensors. (Refer to p.1135)
(Note)

</td></tr>
<tr><td>Correlation between sensing object size and sensing range</td><td>This diagram for the diffuse reflective type sensor gives the correlation between sensing object size and sensing range.
(For sensors having a sensitivity adjuster, the graph is shown for the condition when the sensitivity adjuster is set such that the standard sensing object is just detectable at the maximum sensing distance.)
The graph is useful to determine the sensing distance for which the sensor can stably detect an object considering its size.
(Note)

</td></tr>
</table>

<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>Correlation between lightness and sensing range</td><td>This diagram of the convergent reflective type sensor gives the correlation between lightness and sensing range.
The graph is useful to determine the sensing distance for which the sensor can reliably detect an object considering its lightness.
(Note)


The sensing region is represented by oblique lines in the left figure. However, the sensitivity should be set with enough margin because of slight variation in products.
(Lightness shown on the left may differ slightly from the actual object condition.)</td></tr>
<tr><td>Correlation between material and sensing range</td><td>This diagram of the convergent or the fixed-focus reflective type sensor gives the correlation between object material and sensing range.
The graph is useful to determine the sensing distance for which the sensor can reliably detect an object considering its material.
(Note)


The bars in the graph indicate the sensing range for the respective material. However, there is a slight variation in the sensing range depending on the product. Further, if there is a reflective object (conveyor, etc.) in the background of the sensing object, since it affects the sensing, separate it by more than twice the sensing range shown in the left graph.</td></tr>
<tr><td>Correlation between color and sensing range</td><td>This diagram of the convergent or the fixed-focus reflective type sensor gives the correlation between color and sensing range.
The graph is useful to determine the sensing distance for which the sensor can reliably detect an object considering its color.
(Note)


These bars indicate the sensing range with the respective colors when the distance adjuster is set at the sensing range of 40 mm 1.575 in, 30 mm 1.181 in and 20 mm 0.787 in long, each, with white color.</td></tr>
<tr><td>Correlation between setting distance and excess gain</td><td>Excess gain is a measurement of the sensing energy falling on the receiver element of a sensing system over and above the minimum amount required to operate the sensor.
Excess gain may be used to predict the reliability of any sensing system.
(Note)

</td></tr>
</table>

Note: These are typical graphs, and are subject to slight changes from model to model.

PRECAUTIONS FOR PROPER USE

Setting distance

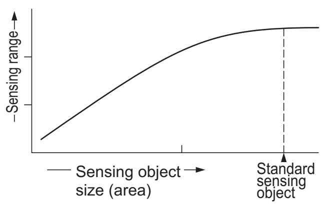
Thru-beam type and retroreflective type sensors

- The setting distance must be equal to or less than the specified sensing range.
  The sensors may be operable at a setting distance longer than the rated sensing range, but reliable operation cannot be guaranteed. Further, in a dirty or dusty environment, the setting should provide margin for beam intensity reduction.

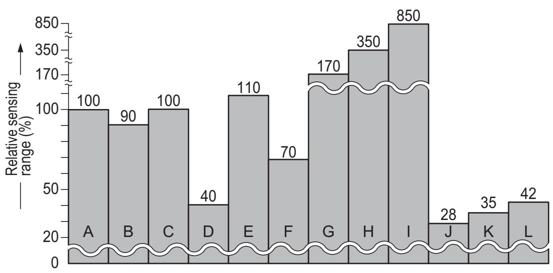
Reflective type sensors

- The sensing range given in the specifications is for the standard sensing object.
  Since the actual sensing distance differs with the size, color, surface condition, etc., of the sensing object, set the sensor giving enough margin for these differences.

- **Change of sensing range with sensing object size**
  The bigger the sensing object size, the larger the quantity of light reflected, which increases the sensing range. However, if the sensing object becomes bigger than the spread of the light beam or the field of vision of the receiver, the sensing range does not increase any further.



- **Change of sensing range with sensing object (Diffuse reflective type sensors)**



A : White non-glossy paper (Standard)
B : Natural color cardboard
C : Plywood
D : Black non-glossy paper (Lightness: 3)
E : Plywood (glossy) Bakelite board (Natural color) Acrylic board (Black) Vinyl leather (Red)
F : Vinyl leather (Gray)
G: Rubber sheet (Green glossy)
H : Aluminum sheet
I : Reflex reflector
J : ϕ10 mm ϕ0.394 in rusted steel rod ϕ5 mm ϕ0.197 in brass pipe
K : Cloth (Black)
L : Cloth (Dark blue)

The above mentioned relative sensing range for different sensing objects has been given taking the sensing range for white non-glossy paper as 100.
The values are given for reference, and would vary slightly with the type of photoelectric sensor, sensing object size, etc.

Mounting

- **Mutual interference**
  If sensors are mounted adjacently, they may affect each other's operation (mutual interference). The following countermeasures are necessary to prevent it.

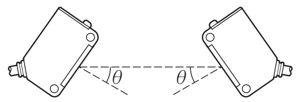
Countermeasure ①: Use sensors having interference prevention function.

When sensors having the interference prevention function are used, two sensors can be mounted close together.
(In case of the **PX-2** series: 26 sensors, **FX-305**: 16 sensors, **SF2-EH** series: 12 sensors, **SF2-N** series: 6 sensors, **FX-301/FX-311/FX-411/LS** series: 4 sensors, **SF4B/SF4-AH/NA1-PK3** series: 3 sensors can be mounted close together.)

List of photoelectric sensors having interference prevention function

	Automatic interference prevention	Interference prevention (with frequency selection switch)	
Series name	• **FX-300** • **FX-411** • **FX-311** • **CX-400** (Excluding thru-beam type sensors) • **LS** • **EQ-500** • **EQ-30** • **RX** Excluding thru-beam type sensors and **RX-LS200** • **NX5** (Excluding thru-beam type sensors) • **SS-A5** • **PX-2** • **CX** (Excluding thru-beam type sensors)	• **FX-11A** • **SF4-AH** • **SF2-EH** • **NA40** • **NA2-N** • **NA1-PK3**	• **SU-7** • **SF2-N** • **SF1-N** • **SF1-F** • **NA1-PK5/5**

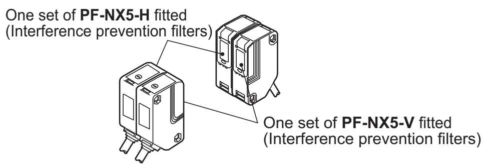
Notes: 1) For the thru-beam type sensors incorporated with a sensitivity adjuster, reduce the sensitivity to a level at which the stability indicators just light up.
2) When two diffuse reflective type sensors face each other, tilt them down.



Countermeasure ②: Use interference prevention filters.

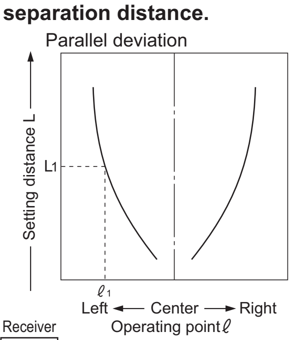
Interference prevention filters are available for **CX-411□**, **NX5-M10RA** and **NX5-M10RB**.

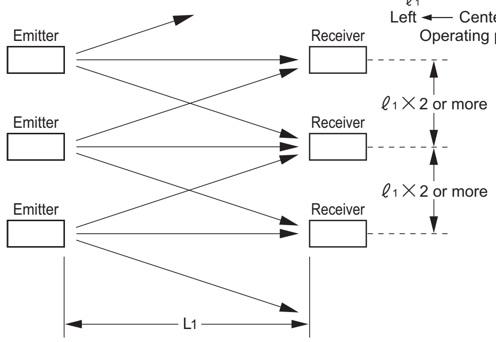
<NX5-M10RA, NX5-M10RB>



Countermeasure ③: Increase the separation distance.

Find out the operating point ℓ_1 on the parallel deviation diagram or the sensing field diagram for the setting distance L_1. Separate sensors by $2 \times \ell_1$ or more.



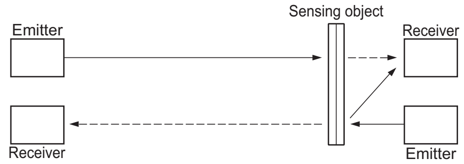


PHOTOELECTRIC SENSORS

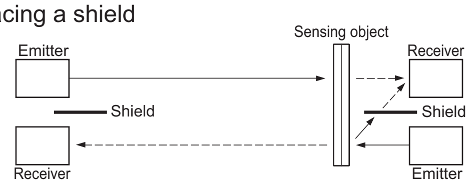
PRECAUTIONS FOR PROPER USE

Countermeasure ④: Place the emitter and the receiver alternately. (Thru-beam type sensors only)

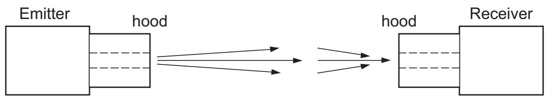
With this arrangement, if a sensing object comes near the sensors, the beam reflected from the sensing object may enter the receiver as shown below. In this case, countermeasures, such as placing a shield between the emitter and the receiver are necessary.



Placing a shield



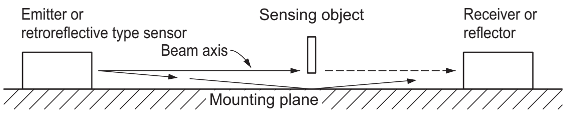
Countermeasure ⑤: Narrow the light beam with a hood or a slit mask. (Thru-beam type sensors only)



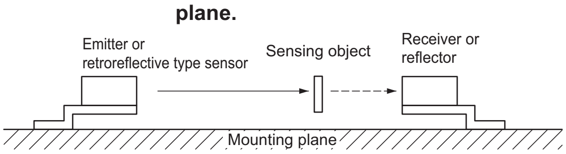
• Influence of surroundings

Thru-beam type and retroreflective type sensors

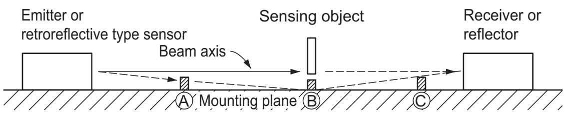
If a thru-beam type sensor, or a retroreflective type sensor is mounted on a flat shiny plane, the emitted beam may not be interrupted by a sensing object because some amount of the emitted beam passes through the gap between the sensing object and the plane, gets reflected from the plane, and enters the receiver.



Countermeasure ①: Increase distance from the mounting plane.



Countermeasure ②: Place light barriers on the mounting plane.

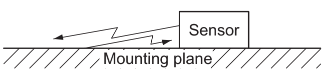


Place light barriers at Ⓐ, Ⓑ and Ⓒ to prevent reflection.

Countermeasure ③: Paint the mounting plane in non-glossy black color.

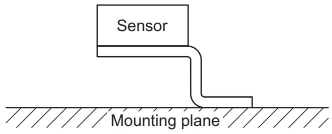
Reflective type sensors

• Effect of mounting plane



If a reflective type sensor is mounted on a rough plane, scatteredly reflected beam returns to the sensor. This causes the hysteresis to increase or the sensor to always remain in the light received condition.

Countermeasure ①: Increase distance from the mounting plane.



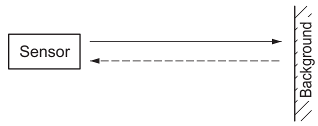
Countermeasure ②: Paint the mounting plane in non-glossy black color.

• Influence of background

If there is a wall, etc., behind the sensing object, the sensor operation may be affected.

Countermeasures:

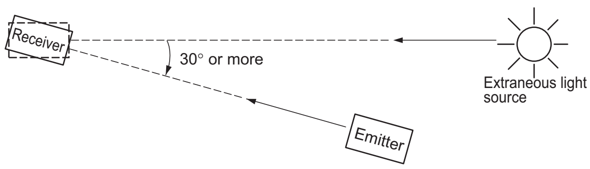
- Remove the background.
- Paint the background in black color.
- Increase the distance from the background.
- Use a fixed-focus sensor or a convergent reflective sensor.



• Influence of extraneous light

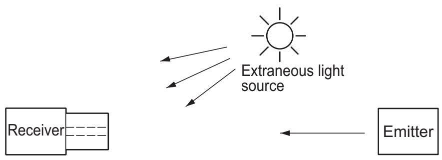
Most of the sensors use modulated beam highly immune to sunlight or ordinary fluorescent light. However, intense light or light from inverter fluorescent lamps may affect the sensor operation.
(The **CX** series is incorporated with an inverter fluorescent light resistant circuitry.)

Countermeasure ①: Tilt the beam axis so that the receiver is not directly facing the extraneous light source.



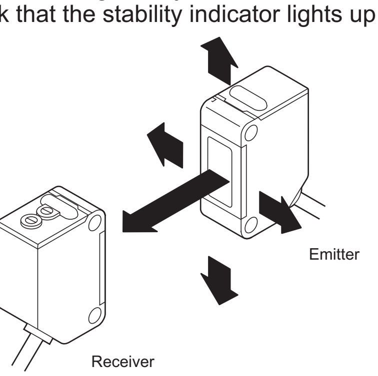
Note that the sunlight incidence angle varies with the season.

Countermeasure ②: Attach a hood on the receiver.



Beam alignment (Thru-beam type and retroreflective type sensors)

① Placing the emitter and the receiver face to face along a straight line, move the emitter in the up, down, left and right directions, in order to determine the range of the beam received condition with the help of the operation indicator. Then, set the emitter at the center of this range.
② Similarly, adjust for up, down, left and right angular movement.
③ Further, perform the angular adjustment for the receiver also.
④ Finally check that the stability indicator lights up.



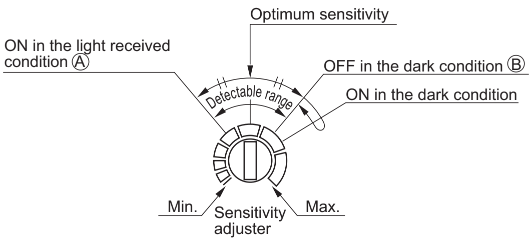
- Perform the beam alignment with a retroreflective type sensor, similarly. Normally, the mirror angle can be set roughly, but the sensor angle must be precisely adjusted.

PRECAUTIONS FOR PROPER USE

Sensitivity adjustment

- Follow the procedure given below while noticing the operation indicator.

① Turn the sensitivity adjuster fully counterclockwise to the minimum sensitivity position.
② In the light received condition, turn the sensitivity adjuster slowly and confirm the point Ⓐ where the sensor enters the 'Light' state operation.
③ In the dark condition, turn the sensitivity adjuster further clockwise until the sensor enters the 'Light' state operation and then bring it back to confirm point Ⓑ where the sensor just returns to the 'Dark' state operation.
(If the sensor does not enter the 'Light' state operation even when the sensitivity adjuster is turned fully clockwise, this extreme position is point Ⓑ.)
④ The position at the middle of points Ⓐ and Ⓑ is the optimum sensing position.
(Turn the adjuster with the accessory screwdriver. The adjuster may be damaged if it is turned beyond its limit with excessive force.)



Type			Light received condition	Dark condition
Thru-beam	Presence detection		Emitter → Receiver	Emitter → Sensing object, Receiver
	Light intensity detection		Emitter, Receiver, Sensing object	Emitter, Receiver, Sensing object
Retroreflective	Presence detection		Sensor ⇄ Reflector	Sensor → Sensing object, Reflector
	Light intensity detection		Sensor, Reflector, Sensing object	Sensor, Reflector, Sensing object
Reflective	Presence detection		Sensor ⇠ Sensing object	Sensor →
	Mark sensing	Red beam	Sensor, Sensing object (White / Yellow / Orange / Red)	Sensor, Sensing object (Black / Blue / Green)
		Green beam	Sensor, Sensing object (White / Yellow / Orange)	Sensor, Sensing object (Black / Blue / Green / Red)

The **FX-300/411** series, **FZ-10** series, **LS** series, **LX-100** series and **SU-7** series incorporate an automatic sensitivity setting function, which allows sensitivity setting just by pressing buttons. For these series, there is no need to follow the above adjustment procedure.

Color discrimination during mark sensing

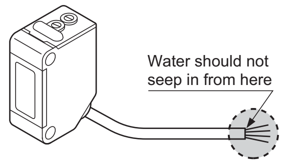
- Marks can be sensed with color fiber sensor **FZ-10** series, mark sensor or fiber sensor.
  The **FZ-10** series uses red, green and blue LEDs to identify a color by its three color components. Hence, it is able to discriminate even minute color differences.
  For mark sensors and fiber sensors, the color combinations of the mark and the background which can be discriminated, depending on the color of the light source, are as given in the table below.

Background color \ Mark color	White	Yellow	Orange	Red	Green	Blue	Black
White		Ⓑ	Ⓑ	ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Yellow	Ⓑ		Ⓖ	Ⓖ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Orange	Ⓑ	Ⓖ		ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Red	ⒼⒷ	Ⓖ	ⒼⒷ		Ⓡ	ⓇⒷ	ⓇⒷ
Green	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	Ⓡ		Ⓑ	Ⓑ
Blue	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ		Ⓑ
Black	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ	Ⓑ	

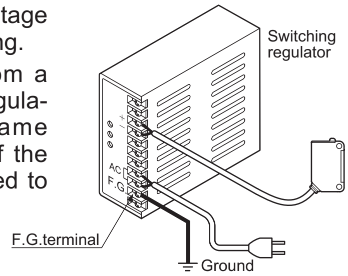
Ⓡ: Red LED type Ⓖ: Green LED type Ⓑ: Blue LED type

Other precautions

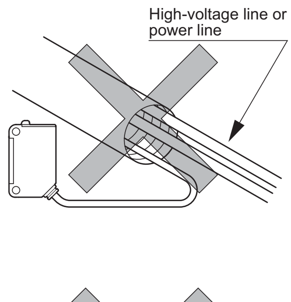
- Although the protection degree is specified for the sensor including the cable, the cable end is not waterproof and is not covered by the protection specified. Hence, make sure that water does not seep in from the cable end.



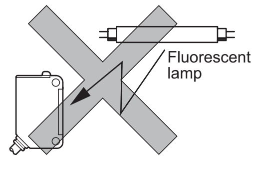
- Make sure that the power supply is off while wiring.
- Verify that the supply voltage variation is within the rating.
- If power is supplied from a commercial switching regulator, ensure that the frame ground (F.G.) terminal of the power supply is connected to an actual ground.



- In case noise generating equipment (switching regulator, inverter motor, etc.) is used in the vicinity of this product, connect the frame ground (F.G.) terminal of the equipment to an actual ground.
- Do not run the wires together with high-voltage lines or power lines or put them in the same raceway. This can cause malfunction due to induction.



- Avoid dust, dirt, and steam.
- Take care that the sensor does not come in direct contact with water, oil, grease or organic solvents, such as, thinner, etc.
- Take care that the sensor is not directly exposed to fluorescent lamp from a rapid-starter lamp or a high frequency lighting device, as it may affect the sensing performance.



- These sensors are suitable for indoor use only.
- Make sure that stress is not applied directly to the sensor cable joint.

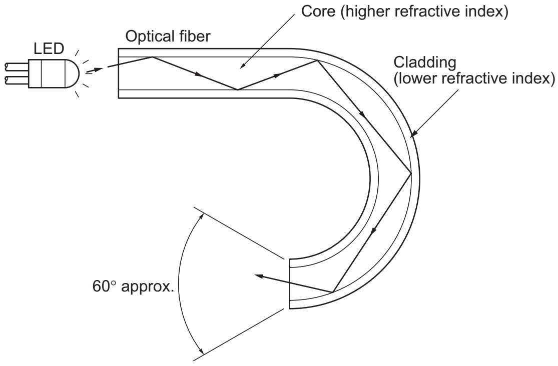
PHOTOELECTRIC SENSORS

PRINCIPLES OF PARTICULAR OPTICAL SENSING SYSTEMS

Fiber cables

Principle of optical fiber

- An optical fiber comprises of a core and a cladding, which have different refractive indexes.
  When light is incident on the core, it propagates in the core by being totally reflected at the boundary between the core and the cladding. After traveling through the fiber, light spreads at an angle of approx. 60° at the cable end and is directed on the sensing object.

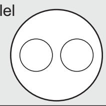
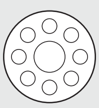
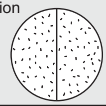


Types of fiber cables and their features

Type	Features
Plastic	The fiber is made of acrylic. The cable may consist of a single or multiple fiber strands of ϕ0.125 ϕ0.005 to ϕ1.5 mm ϕ0.059 in. It is widely used because of its low price. The sharp bending fiber is made up of several hundred ϕ0.075 mm ϕ0.003 in acrylic resin fibers bound together into a single multi-core fiber, so that it can be bend at right angles without causing a decrease in light intensity or breaking.
Glass	The fiber is made of glass that provides better heat-resistance and chemical-resistance than plastic. The cable consists of multiple fiber strands of ϕ0.05 mm ϕ0.002 in. It is used mainly for special applications because of its high price.

Fiber cable structure

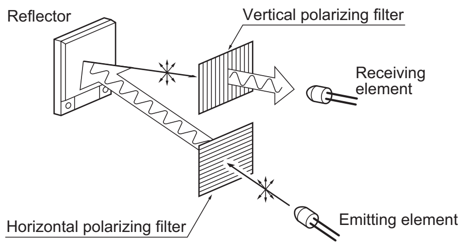
- Fiber sensors are classified broadly into two groups thru-beam type and reflective type.
  The thru-beam type has two fiber cables: the emitting cable and the receiving cable. The reflective type has one fiber cable that contains, both, the emitting part and the receiving part.
  The cable can be classified into parallel, coaxial or partition types, depending on the structural arrangement of the fiber strands.

Cable structure	Description
Parallel 	Generally used for plastic fiber cables.
Coaxial 	The center fiber is for beam emission, and the surrounding fibers are for receiving the beam. This structure is suitable for high accuracy measurements since the sensing position does not change with the travel direction of the sensing object.
Partition 	Generally used for glass fiber cable. It comprises of a number of glass fiber strands of ϕ0.05 mm ϕ0.002 in, and is divided into the emitting part and the receiving part.

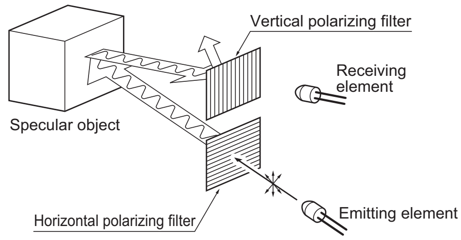
Retroreflective type sensor with polarizing filters

Principle

- Opposite types of polarizing filters are placed in front of the emitting and receiving elements. A horizontal polarizing filter placed in front of the emitting element passes only horizontally polarized light and a vertical polarizing filter placed in front of the receiver ensures that only vertically polarized light is received. Using this configuration, even specular objects can be reliably detected.
  ① Normal unpolarized beam emitted from the LED oscillates in a random manner. As it passes through the horizontal polarizing filter, the oscillation is aligned horizontally and the beam is horizontally polarized.
  ② When the polarized beam falls on the reflector, its polarization is destroyed and the reflected beam oscillates in a random manner. So, the reflected beam can pass through the vertical polarizing filter and reach the receiving element.

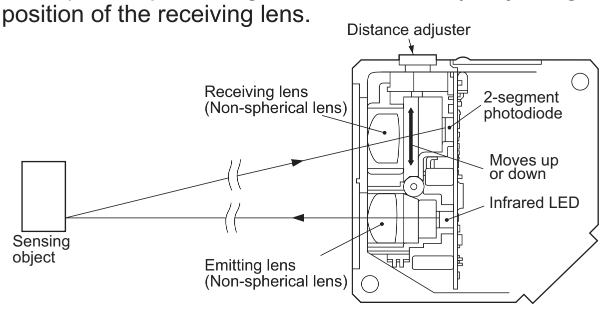


However, a specular object does not destroy the polarization. The reflected beam oscillates horizontally, as before, and cannot pass through the vertical polarizing filter.



Adjustable range & fixed-focus reflective type photoelectric sensor

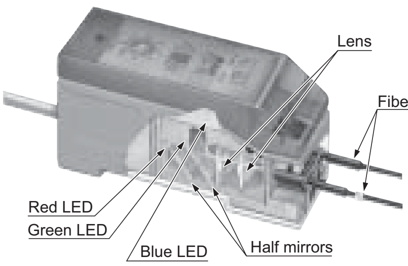
- Employing the optical triangulation method, it reliably senses an object at a given distance, irrespective of its reflectivity, by measuring the angle of the received beam. It contains an emitting lens and a receiving lens. The beam from the emitting lens falls on the sensing object and, after being reflected, is guided by the receiving lens onto a 2-segment diode. Here, the sensing object distance is determined by taking the position at which the upper and lower segments of the 2-segment photodiode generate equal output voltages as the reference.
  This method, besides being suitable for long distance, is also good for high accuracy position alignment. Further, the equal output voltages are obtained by adjusting the position of the receiving lens.



PRINCIPLES OF PARTICULAR OPTICAL SENSING SYSTEMS

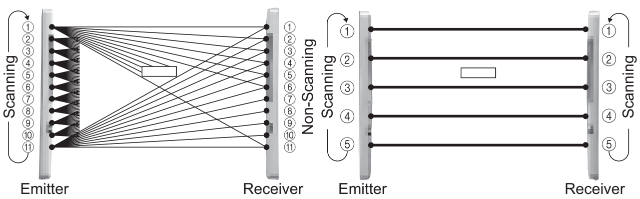
Color sensor

- Three LEDs, red, green and blue, are used as the emitting elements. Each of them emit in turn to illuminate the sensing object and the color components of the reflected beam are processed to determine the sensing object color.



Cross-beam scanning

- This is a modified type of light curtain. Although the emitter and the receiver each consist of an array of elements, only the emitting elements are scanned and light from one emitting element is received by all the receiving elements. If light is not received even by one receiving element, it results in light interrupted state. Hence, even thin objects, such as postcards, can also be detected.



Liquid level detection sensor (pipe-mountable type)

Thru-beam type

- When liquid is present, the lens focuses as per the liquid lens effect and the beam is received.

<Filled pipe> **<Empty pipe>**

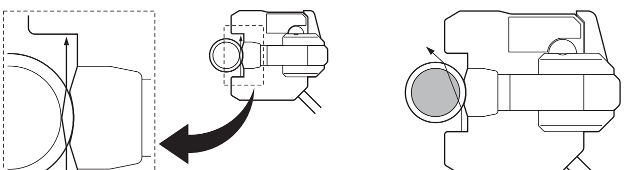
The lens focuses as per the liquid lens effect and the beam is received.

The beam is scattered and not received.

Reflective type

- When the pipe is empty, the beam is reflected from the inner surface of the pipe wall and returns to the beam-receiving part since the difference in the refractive indexes of the pipe and air is large.
  When there is liquid in the pipe, the beam enters the liquid through the wall and does not return to the beam-receiving part as the difference in the refractive indexes of the pipe and the liquid is small.

<Empty pipe> **<Filled pipe>**

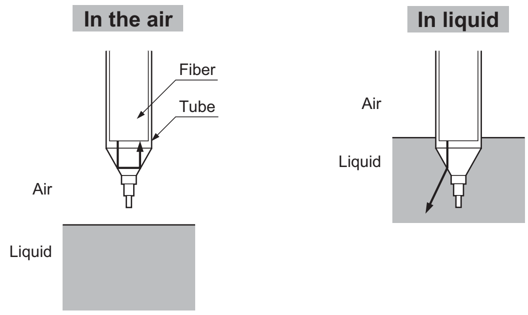


The beam reflected from the inner surface of the pipe wall returns to the beam-receiving part.

The beam passes through the wall into the liquid.

Liquid level detection fiber (Contact type)

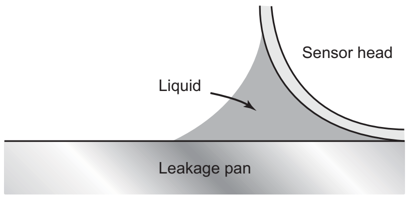
- When the fiber tip is in the air, as there is a large difference between the air and the tube refractive indexes, the tube boundary reflects the emitted beam back to the receiver. On the other hand, when the fiber tip is immersed in a liquid, the emitted beam scatters from the fiber into the liquid because of the small difference in the liquid and the tube refractive indexes.



Leak liquid detection (Leak detection fiber / Leak detection sensor)

- The unique effect of capillarity enables reliable detection of small leaks and viscous liquids.

Capillarity effect

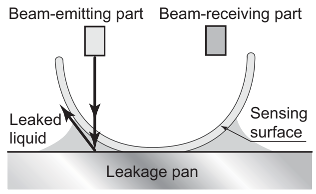


New Type of Detection Method

- When a leak occurs, the beam from the beam-emitting part scatters through the leaked liquid and is not transmitted to the beam-receiving part.

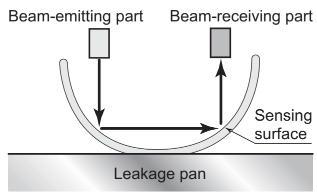
When leakage occurs

The beam from the beam-emitting part scatters through the leaked liquid and is not transmitted to the beam-receiving part.



When there is no leakage

The beam from the beam-emitting part reflects off of the surface of the sensor and is transmitted to the beam-receiving part.



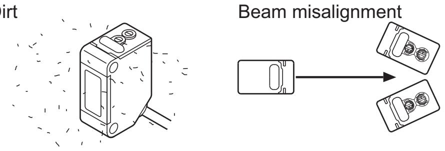
FUNCTIONS

Function	Description

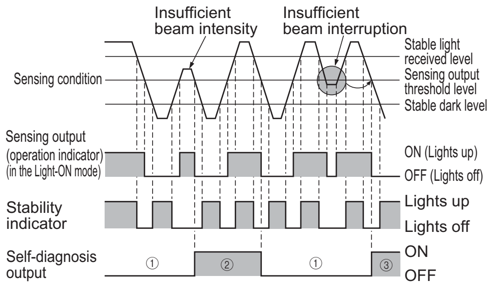
Self-diagnosis function

The sensor diagnoses the incident light intensity, and if it is reduced due to dust or dirt, or beam misalignment, a visual indication and/or an output is generated.

Dirt Beam misalignment



• Time chart



① The self-diagnosis output transistor stays in the 'OFF' state ('ON' state in case of **SS-A5**) during stable sensing.
② When the sensing output changes, if the incident light intensity does not reach the stable light received level or the stable dark level, the self-diagnosis output becomes ON (OFF in case of **SS-A5**).
Further, the self-diagnosis output changes state when the sensing output changes from Light to Dark state. (It is not affected by the operation mode switch.)
③ In case of insufficient beam interruption, there will be a time lag before the self-diagnosis output turns ON.

- The **SF4-AH** series, **SF2-A** series, **SF2-N** series, **SF2-EH** series, etc., have a self-diagnosis function for the internal circuitry besides the above mentioned self-diagnosis function for the beam intensity.
- Since the time chart differs with the sensor model, please refer to the section '**PRECAUTIONS FOR PROPER USE**' of the respective sensor series.

Light intensity monitor

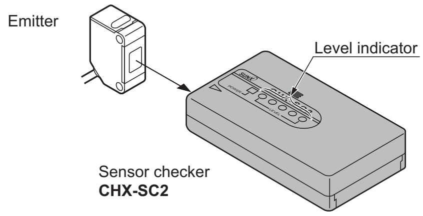
Incident light intensity can be displayed numerically or by an LED array.

FX-301

Incident light intensity can be shown on a digital display (4 digit LED).

Infrared or red beam type of thru-beam photoelectric sensors

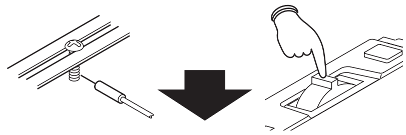
Using the optional sensor checker **CHX-SC2**, the incident light intensity can be checked audio-visually.



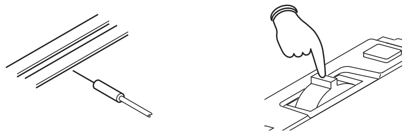
Automatic sensitivity setting

Sensitivity setting is done simply by pressing a button.

Press the jog switch with the object in front of the fiber.



Press the jog switch without the object.

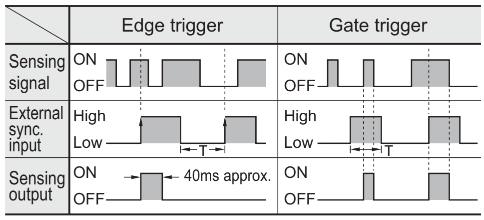


The **FX-300** series, **LS** series and **LX-100** series feature a full auto-teaching function by which sensitivity setting can be done on a moving object without stopping the assembly line. Further, in case of the **FZ-10** series and **SU-7** series, sensitivity setting is done by using a button switch.

External synchronization function

The timing of sensing can be controlled.

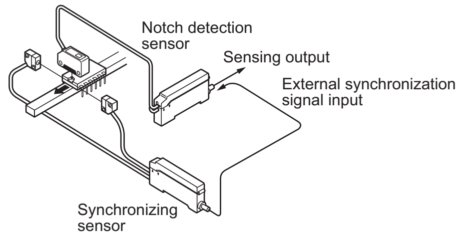
• Time chart (with SU-75)



T ≧ 0.6 ms (when the interference prevention function is used, T ≧ 0.8 ms)

• Application

Checking orientation of IC

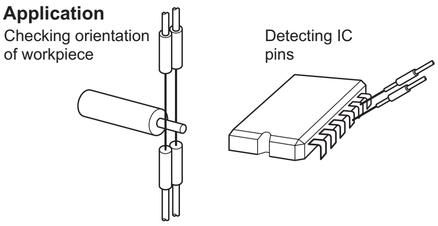


Interference prevention function

When several photoelectric sensors are mounted close together, mutual interference can be prevented by setting different emission frequencies. Interference prevention function by which the emission frequency can be changed by a switch or an interference prevention wire, or, automatic interference prevention function by which the frequency is automatically changed by the sensor are available.

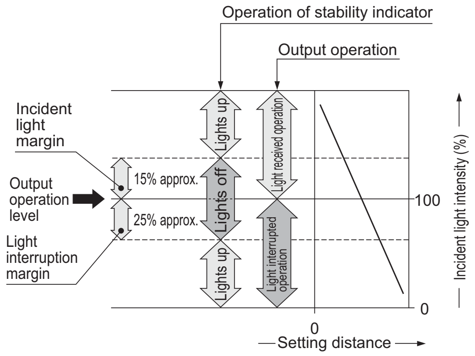
• Application

Checking orientation of workpiece Detecting IC pins



FUNCTIONS

<table>
<tr><th>Function</th><th>Description</th></tr>
<tr><td>Stability indicator</td><td>
The stability indicator (green) lights up when the incident light intensity has sufficient margin with respect to the operation level. If the incident light intensity level is such that the stability indicator lights up, stable sensing can be done without the light received operation and the light interrupted operation being affected by a change in ambient temperature or supply voltage.



• In case of the **NA2-N** series, **NA1-PK5/5** series and **NA1-PK3** series, this is the stable incident beam indicator and lights up when the incident light margin is exceeded.
</td></tr>
<tr><td>Timer function</td><td>
The width of the output signal is controlled to match the connected device specifications.

ON-delay

Function: Neglects short output signals.
Application: As only longer signals are extracted, this function is useful for detecting if a line is clogged, or for sensing only objects taking a long time to travel.
(e.g.) Sensing of jamming in an assembly line

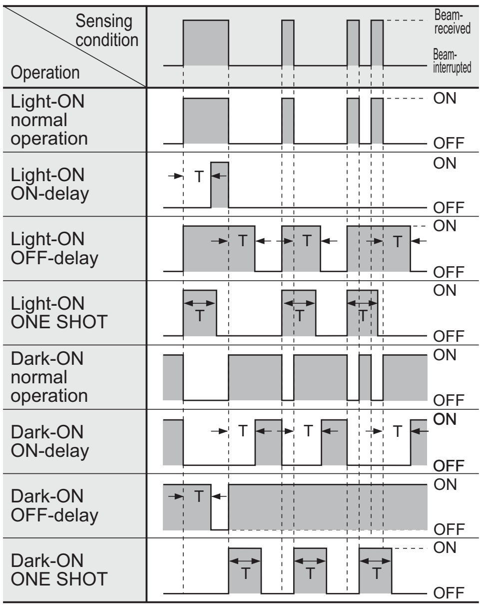
OFF-delay

Function: Extends the output signal for a fixed period of time.
Application: This function is useful if the output signal is so short that the connected device cannot respond.

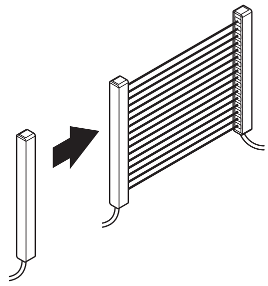
ONE SHOT

Function: Outputs a fixed width signal upon sensing
Application: This function is useful when the input specifications of the connected device require a signal of fixed width. Of course, it is also useful for extending a short width signal to a desired width.

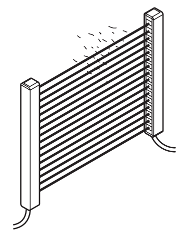
• **Time chart** T: Timer period



The **FX-305** is equipped with an ON-delay / OFF-delay timer that allows you to use ON-delay and OFF-delay simultaneously as well as an ON-delay / ONE SHOT timer enabling a simultaneous ON-delay and ONE SHOT.
</td></tr>
<tr><td>Automatic sensitivity compensation function</td><td>
The sensitivity is adjusted according to the setting distance to maintain the optimum sensitivity.

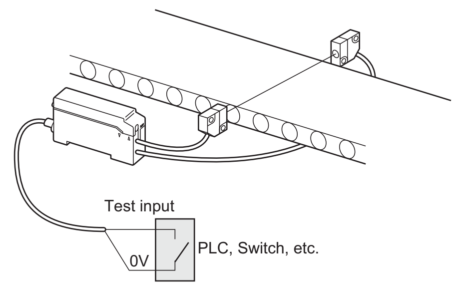


The sensitivity is reduced if the emitter and the receiver are brought closer.

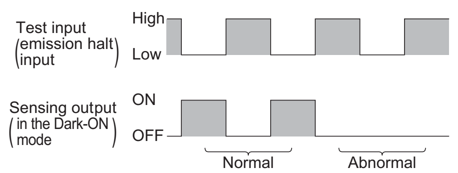


The sensitivity is increased in case of dust or dirt.
</td></tr>
<tr><td>Test input (emission halt input)</td><td>
The emission can be stopped by an external test input.

• **Application**
Start-up inspection



• **Time chart**



When several sensors are arrayed in a line, this function can also be used for mutual interference prevention by controlling the beam emission in a cyclic manner.
</td></tr>
</table>

Item	Series name	FX-301	FX-311	FX-11A	FZ-10	CX-400	EX-30	EX-20	EX-10	EQ-30	EX-40	RX	RX-LS200	CY	PX-2	RT-610	PM
Type		Fiber sensors				Photoelectric sensors											
		Digital setting	Manually set	Analog output	Color detection	Amplifier built-in											Micro
Self-diagnosis	Light intensity											○					
	Internal circuit																
Light intensity monitor	Digital display	◎															
	LED array & buzzer					○ (Note)	○ (Note)	○ (Note)	○ (Note)			○ (Note)		○ (Note)			
Automatic sensitivity setting		◎			◎												
External sync.	Edge trigger																
	Gate trigger																
Interference prevention		◎	◎	◎		◎				◎		○			◎		
Stability indicator		◎	◎			◎	◎	◎	◎	◎	◎	◎	◎				
Timer	ON-delay	◎															
	OFF-delay	◎	◎		◎						○						
	ONE SHOT	◎															
	ON-delay / OFF-delay																
	ON-delay / ONE SHOT																
Automatic sensitivity compensation																	
Test input												○		○			

Item	Series name	PM2	NX5	VF	EQ-500	SU-7/SH	SS-A5	SF4-AH	SF2-A	SF2-N	SF2-EH	SF1-F	NA2-N	NA1-11	NA1-PK5/5	NA1-PK3	M-DW1
Type		Photoelectric sensors						Light curtains for safeguard					Area sensors				Sensors for semiconductor industry
		Micro	Power supply built-in			Amplifier-separated							Individual beam outputs	Slim body	Picking		Glass substrate / wafer sensing
Self-diagnosis	Light intensity					◎	◎	◎	◎	◎	◎						
	Internal circuit							◎	◎	◎	◎						
Light intensity monitor	Digital display																
	LED array & buzzer		○ (Note)	○ (Note)		○ (Note)	○ (Note)	◎	◎	◎							
Automatic sensitivity setting						◎											
External sync.	Edge trigger					○											
	Gate trigger					○											
Interference prevention			○		◎	◎	◎	◎		◎	◎	◎	◎		◎	◎	
Stability indicator			◎		◎	◎	◎	◎	◎	◎	◎		◎		◎	◎	◎
Timer	ON-delay			○	○	○											
	OFF-delay			○	○	○	◎										
	ONE SHOT			○													
	ON-delay / OFF-delay				○												
	ON-delay / ONE SHOT																
Automatic sensitivity compensation																	
Test input						○		◎	◎	◎	◎						

Item	Series name	FT-K□	FD-L43	FD-L41	SH-72	M	HD-T1	EX-F70/F60	FD-F705	FT-F902	FX-301-F	EX-F1	FD-F4□	FD-F8Y	FT-Z8Y	FD-H30-L32, FD-H18-L31	EZ-10
Type		Sensors for semiconductor industry															
		Glass substrate / wafer sensing					Leak liquid / Liquid level sensing									Chemical-resistant	Heat-resistant
Self-diagnosis	Light intensity				◎												
	Internal circuit																
Light intensity monitor	Digital display	○	○	○					◎	◎	◎		○	○	○	○	
	LED array & buzzer																
Automatic sensitivity setting		○	○	○	○				◎	◎	◎		○	○	○	○	
External sync.	Edge trigger				○												
	Gate trigger				○												
Interference prevention		◎	◎	◎	◎				◎	◎	◎		◎	◎	◎	◎	
Stability indicator		◎	◎	◎	◎				◎	◎	◎		◎	◎	◎	◎	◎
Timer	ON-delay	○	○	○	○								○	○	○	○	
	OFF-delay	○	○	○	○				◎	◎	◎		○	○	○	○	
	ONE SHOT	○	○	○									○	○	○	○	
	ON-delay / OFF-delay	○	○	○									○	○	○	○	
	ON-delay / ONE SHOT	○	○	○									○	○	○	○	
Automatic sensitivity compensation																	
Test input					○	◎											

Note: By using sensor checker **CHX-SC2**.

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