

What Is a Photoelectric Sensor?

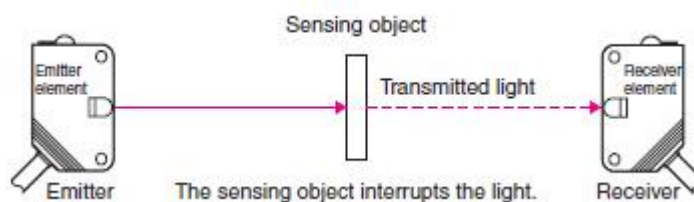
Photoelectric Sensors detect objects, changes in surface conditions, and other items through a variety of optical properties.

A Photoelectric Sensor consists primarily of an Emitter for emitting light and a Receiver for receiving light. When emitted light is interrupted or reflected by the sensing object, it changes the amount of light that arrives at the Receiver. The Receiver detects this change and converts it to an electrical output. The light source for the majority of Photoelectric Sensors is infrared or visible light (generally red, or green/blue for identifying colours).

Photoelectric through-beam sensors

Photoelectric sensors with a separate transmitter and receiver are placed facing each other. This is also called a thru-beam configuration. When an object obstructs the light beams, the output will switch. Thru-beam photoelectric sensors can be found in all sorts of applications. Specifically, these with buildup of dirt, liquids and moist or other challenging factors such as ambient lighting. The reason for this is the fact that thru-beam sensors are very reliable, even in challenging applications, such as rollercoasters.

Some transmitter and receiver photoelectric sensors are so powerful that they can bridge an operating range of 70 meters. Therefore, a thru-beam sensor is very suitable for use in the most demanding or dirty environments. When a separate transmitter/receiver is used in combination with a separate amplifier, more functions are possible. Such as: multiple output, filtering and timeout or alarm functions. An additional advantage is that 30 thru-beam sensors can be used next to each other without the sensors interfering.

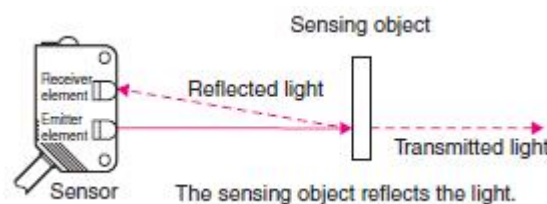


Photoelectric diffuse proximity sensors

Diffuse proximity photoelectric sensors are sensors that detect an object diffusely. These sensors consist of a transmitter or receiver in same housing. No separate receiver, reflector or taught background is used in detections.

A diffuse proximity sensor has various names in the market, such as diffuse proximity switch, proximity switch or reflex sensor. The principle of the photoelectric diffuse proximity sensor is based on object reflection and the transmitter and receiver are positioned side by side in the housing.

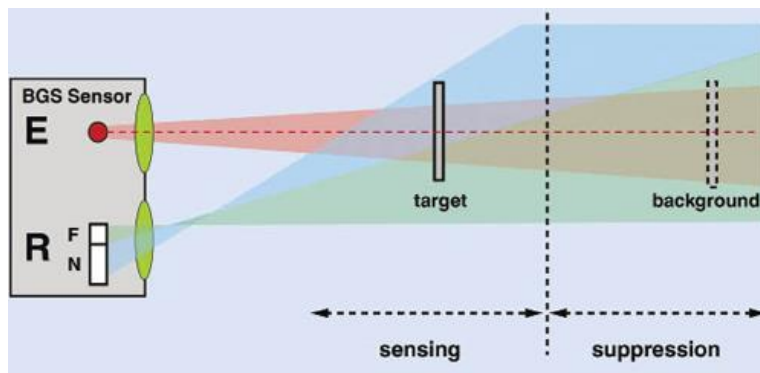
Typically, proximity sensors have a range of around 1 meter. Stronger photoelectric diffuse proximity sensors can have a maximum range up to 5 meters with a switching frequency of 250 Hz.



Photoelectric with Background suppression

Photoelectric sensors with a background suppression function as a photoelectric sensor with diffuse proximity or reflex barriers, with an additional function. These sensors only detect objects within a defined zone. The sensor detects everything that passes between the sensor and the taught background. Ideal for use if you have, for example:

- A blackened baking tray, to be detected
- Want to detect a stainless-steel tray in a rusty environment;
- To detect the presence or absence of a product in an environment of glass.
- Technically, the background is used optimally. By learning (teach) the sensor on the background, it sees everything that passes before.

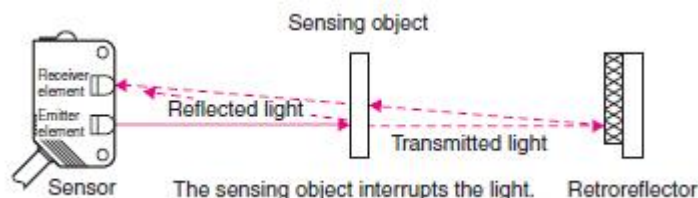


Photoelectric retro-reflective & polarized sensors

With retro-reflective photoelectric sensors, or photoelectric sensors with a reflector, the transmitter and receiver are in one housing. However, the sensor always looks at a reflector instead of an object. The reflector is placed directly opposite of the photoelectric sensor. When the light beam is interrupted, the sensor switches.

Some photoelectric sensors with reflector can be designed as polarized or retro-reflective (non-polarized) sensors.

Polarized sensors are equipped with a special polarizing filter, so that the receiver only accepts light reflected from the polarized reflector. This way it is prevented that switching takes place, for example by someone with reflective clothing. But also, the metallic paint of a car or bare metal are examples of this. The polarizing filter can also detect transparent and reflective objects such as glass or plastic packaging. A retro-reflective reflector reflects the received light exactly as it is received. Regardless of the angle. The light beam from the transmitter of a retro-reflective sensor is therefore reflected directly via the reflector to the receiver of the sensor. When the light beam is intercepted by an object, a switching occurs.



Features

1. Long Sensing Distance

A Through-beam Sensor, for example, can detect objects more than 10 m away. This is impossible with magnetic, ultrasonic, or other sensing methods.

2. Virtually No Sensing Object Restrictions

These Sensors operate on the principle that an object interrupts or reflects light, so they are not limited like Proximity Sensors to detecting metal objects. This means they can be used to detect virtually any object, including glass, plastic, wood, and liquid.

3. Fast Response Time

The response time is extremely fast because light travels at high speed and the Sensor performs no mechanical operations because all circuits are comprised of electronic components.

4. High Resolution

The incredibly high resolution achieved with these Sensors derives from advanced design technologies that yielded a very small spot beam and a unique optical system for receiving light. These developments enable detecting very small objects, as well as precise position detection.

5. Non-contact Sensing

There is little chance of damaging sensing objects or Sensors because objects can be detected without physical contact.

This ensures years of Sensor service.

6. Colour Identification

The rate at which an object reflects or absorbs light depends on both the wavelength of the emitted light and the colour of the object. This property can be used to detect colours.

7. Easy Adjustment

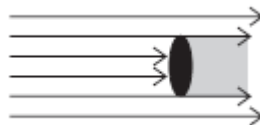
Positioning the beam on an object is simple with models that emit visible light because the beam is visible.

Operating Principles

(1) Properties of Light

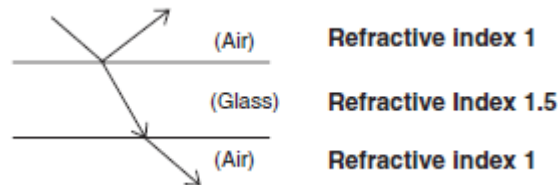
Rectilinear Propagation

When light travels through air or water, it always travels in a straight line. The slit on the outside of a Through-beam Sensor that is used to detect small objects is an example of how this principle is applied to practical use.



Refraction

Refraction is the phenomenon of light being deflected as it passes obliquely through the boundary between two media with different refractive indices.



Reflection

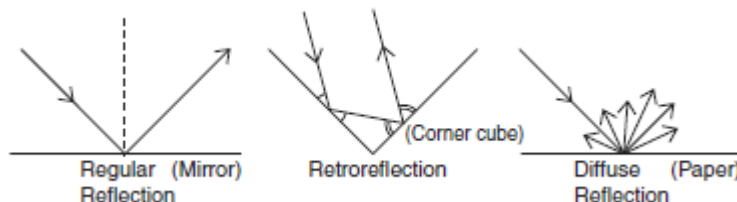
(Regular Reflection, Retroreflection, Diffuse Reflection)

A flat surface, such as glass or a mirror, reflects light at an angle equal to the incident angle of the light. This kind of reflection is called regular reflection. A corner cube takes advantage of this principle by arranging three flat surfaces perpendicular to each other. Light emitted toward a corner cube repeatedly propagates regular reflections and the reflected light ultimately moves straight back toward the emitted light. This is referred to as retroreflection.

Most retroreflectors are comprised of corner cubes that measure several square millimeters and are arranged in a precise configuration.

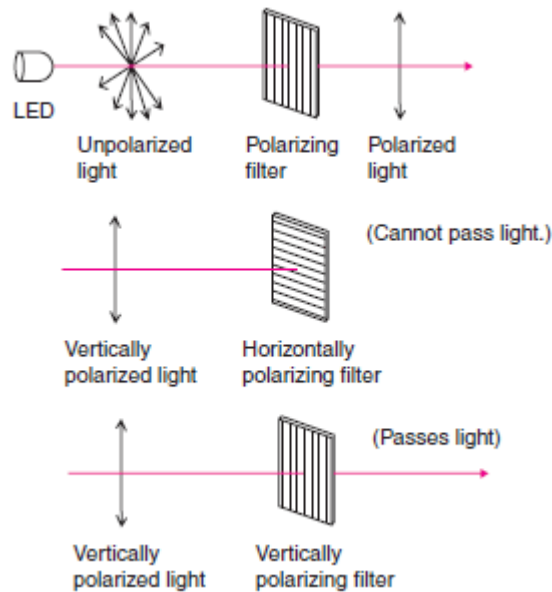
Matte surfaces, such as white paper, reflect light in all directions. This scattering of light is called diffuse reflection.

This principle is the sensing method used by Diffuse-reflective Sensors.



Polarization of Light

Light can be represented as a wave that oscillates horizontally and vertically. Photoelectric Sensors almost always use LEDs as the light source. The light emitted from LEDs oscillates in the vertical and horizontal directions and is referred to as unpolarized light. There are optical filters that constrain the oscillations of unpolarized light to just one direction. These are known as polarizing filters. Light from an LED that passes through a polarizing filter oscillates in only one direction and is referred to as polarized light (or more precisely, linear polarized light). Polarized light oscillating in one direction (say the vertical direction) cannot pass through a polarizing filter that constrains oscillations to a perpendicular direction (e.g., the horizontal direction). The MSR function on Retro-reflective Sensors and the Mutual Interference Protection Filter accessory for Through-beam Sensors operate on this principle.



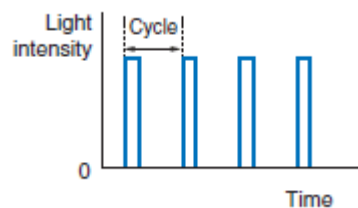
(2) Light Sources

Light Generation

Pulse Modulated light

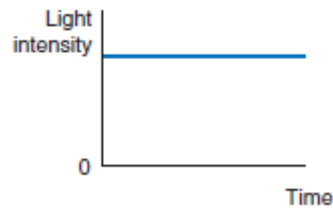
The majority of Photoelectric Sensors use pulse modulated light that basically emits light repeatedly at fixed intervals.

They can sense objects located some distance away because the effects of external light interference are easily removed with this system. In models equipped with mutual interference protection, the emission cycle is varied within a specified range to handle coherent light and external light interference.

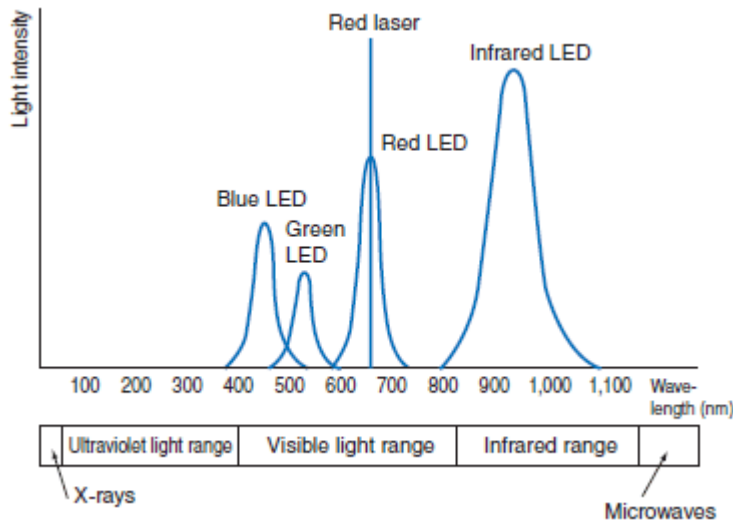


Non-modulated Light

Non-modulated light refers to an uninterrupted beam of light at a specific intensity that is used with certain types of Sensors, such as Mark Sensors. Although these Sensors have fast response times, their drawbacks include short sensing distances and susceptibility to external light interference.



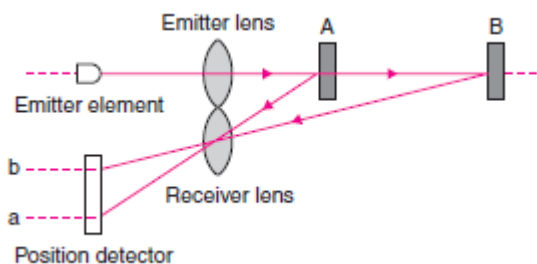
Light Source Color and Type



(3) Triangulation

Distance-settable Sensors generally operate on the principle of triangulation. This principle is illustrated in the following diagram.

Light from the Emitter strikes the sensing object and reflects diffused light. The Receiver lens concentrates the reflected light on the position detector (a semiconductor that outputs a signal according to where the light strikes it). When the sensing object is located at A near the optical system, then the light is concentrated at point a on the position detector. When the sensing object is located at B away from the optical system, then the light is concentrated at point b on the position detector.



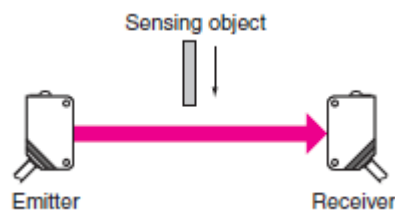
Classification

(1) Classification by Sensing Method

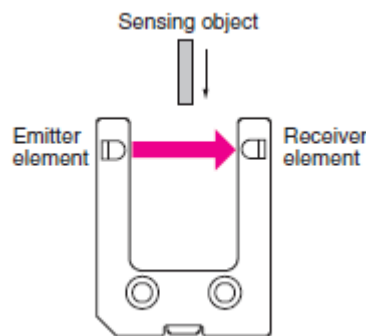
1. Through-beam Sensors

Sensing Method

The Emitter and Receiver are installed opposite each other to enable the light from the Emitter to enter the Receiver. When a sensing object passing between the Emitter and Receiver interrupts the emitted light, it reduces the amount of light that enters the Receiver. This reduction in light intensity is used to detect an object.



The sensing method is identical to that of Through-beam Sensors and some models called Slot Sensors are configured with an integrated Emitter and Receiver.



Features

Stable operation and long sensing distances ranging from several centimeters to several tens of meters.

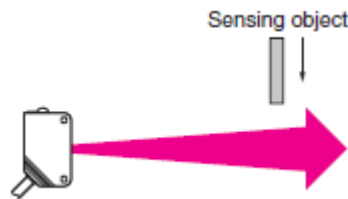
Sensing position unaffected by changes in the sensing object path.

Operation not greatly affected by sensing object gloss, color, or inclination.

2. Diffuse-reflective Sensors

Sensing Method

The Emitter and Receiver are installed in the same housing and light normally does not return to the Receiver. When light from the Emitter strikes the sensing object, the object reflects the light and it enters the Receiver where the intensity of light is increased. This increase in light intensity is used to detect the object.



Features

Sensing distance ranging from several centimeters to several meters.

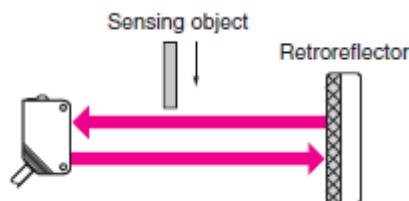
Easy mounting adjustment.

The intensity of reflected light, operating stability, and sensing distance vary with the conditions (e.g., color and smoothness) on the surface of the sensing object.

3. Retro-reflective Sensors

Sensing Method

The Emitter and Receiver are installed in the same housing and light from the Emitter is normally reflected back to the Receiver by a Reflector installed on the opposite side. When the sensing object interrupts the light, it reduces the amount of light received. This reduction in light intensity is used to detect the object.



Features

Sensing distance ranges from several centimeters to several meters.

Simple wiring and optical axis adjustment (labor saving).

Operation not greatly affected by the color or angle of sensing objects.

Light passes through the sensing object twice, making these Sensors suitable for sensing transparent objects.

Sensing objects with a mirrored finish may not be detected because the amount of light reflected back to the Receiver from such shiny surfaces makes it appear as though no sensing object is present. This problem can be overcome using the MSR function.

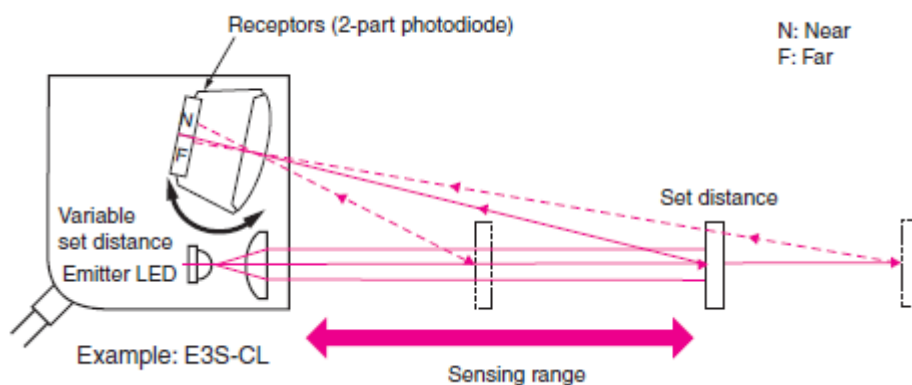
Retro-reflective Sensors have a dead zone at close distances.

4. Distance-settable Sensors

Sensing Method

The Receiver in the Sensor is either a 2-part photodiode or a position detector. The light reflected from the sensing object is concentrated on the Receiver. Sensing is based on the principle of triangulation, which states that where the beam is concentrated depends on the distance to the sensing object.

The following figure shows a detection system that uses a 2-part photodiode. The end of the photodiode nearest the case is called the N (near) end and the other end is called the F (far) end. When a sensing object reaches the preset position, the reflected light is concentrated midway between the N end and the F end and the photodiodes at both ends receive an equal amount of light. If the sensing object is closer to the Sensor, then the reflected light is concentrated at the N end. Conversely, the reflected light is concentrated at the F end when the sensing object is located farther than the preset distance. The Sensor calculates the difference between the light intensity at the N end and F end to determine the position of the sensing object.



Features

Operation not greatly affected by sensing object surface conditions or color.

Operation not greatly affected by the background.

BGS (Background Suppression) and FGS (Foreground Suppression)

In some applications BGS or FGS function is required, to detect objects on a conveyor belt for example. The BGS function prevents any background object (i.e., the conveyor) beyond the set distance from being detected.

The FGS function prevents objects closer than the set distance or objects that reflect less than a specified amount of light to the Receiver from being detected.

Objects that reflect less than a specified amount of light are as follows:

- (1) Objects with extremely low reflectance and objects that are darker than black paper.
- (2) Objects like mirrors that return virtually all light back to the Emitter.
- (3) Uneven, glossy surfaces that reflect a lot of light but disperse the light in random directions.

Reflected light may return to the Receiver momentarily for item (3) due to sensing object movement. In that case, an OFF delay timer or some other means may need to be employed to prevent chattering.

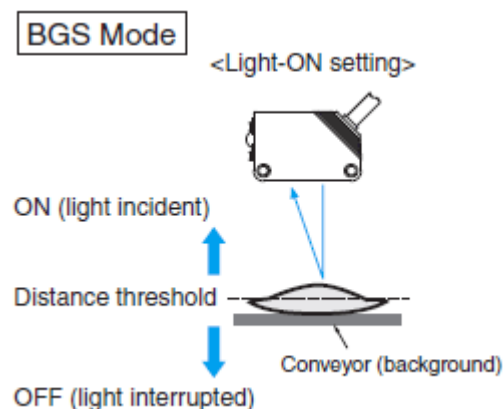
Features

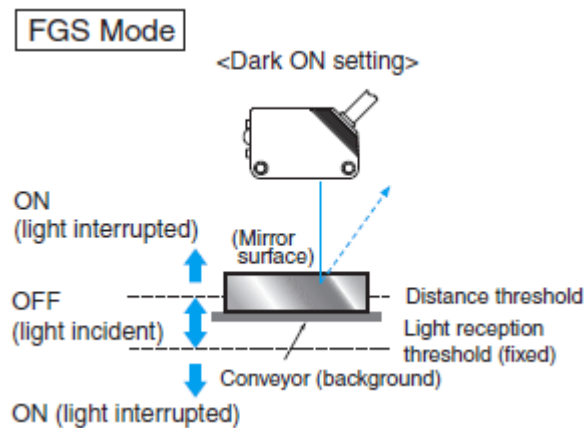
Small differences in height can be detected (BGS and FGS).

The effects of sensing object color are minimized (BGS and FGS).

The effects of background objects are minimized (BGS).

Sensing object irregularities may affect operation (BGS and FGS)

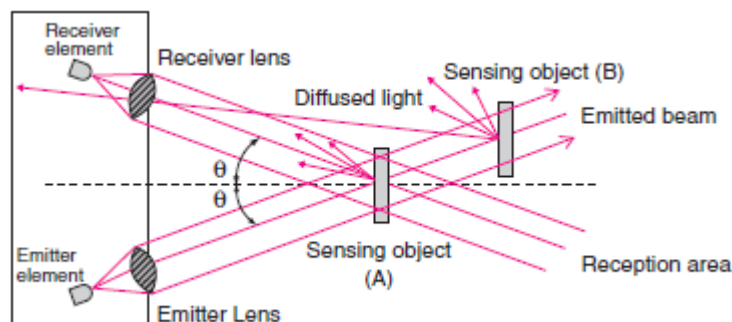




5. Limited-reflective Sensors

Sensing Method

In the same way as for Diffuse-reflective Sensors, Limited-reflective Sensors receive light reflected from the sensing object to detect it. The optical system restricts the light emission and reception area, so only objects that are a specific distance (area where light emission and reception overlap) from the Sensor can be detected. In the figure on the right, the sensing object at (A) can be detected while the object at (B) cannot.



Features

Small differences in height can be detected.

The distance from the Sensor can be limited to detect only objects in a specific area.

Operation is not greatly affected by sensing object colors.

Operation is greatly affected by the glossiness or inclination of the sensing object.

(2) Selection Points by Sensing Method

Checkpoints for Through-beam and Retro-reflective Sensors

Sensing object

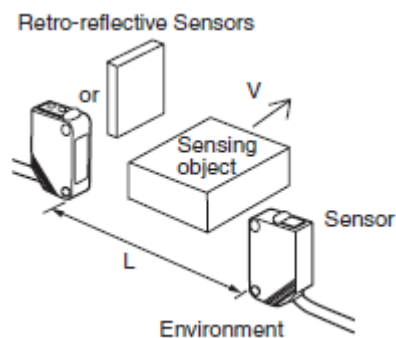
- (1) Size and shape (vertical x horizontal x height)
- (2) Transparency (opaque, semi-transparent, transparent)
- (3) Velocity V (m/s or units/min.)

Sensor

- (1) Sensing distance (L)
- (2) Restrictions on size and shape
 - a) Sensor
 - b) Retroreflector (for Retro-reflective Sensors)
- (3) Need for side-by-side mounting
 - a) No. of units
 - b) Mounting pitch
 - c) Need for staggered mounting
- (4) Mounting restrictions (angling, etc.)

Environment

- (1) Ambient temperature
- (2) Presence of splashing water, oil, or chemicals
- (3) Others



Checkpoints for Diffusion-reflective, Distance-settable, and Limited-reflective Sensors

Sensing object

- (1) Size and shape (vertical x horizontal x height)
- (2) Color
- (3) Material (steel, SUS, wood, paper, etc.)
- (4) Surface conditions (textured or glossy)
- (5) Velocity V (m/s or units/min.)

Sensor

- (1) Sensing distance (distance to the workpiece) (L)
- (2) Restrictions on size and shape
- (3) Need for side-by-side mounting
 - a) No. of units
 - b) Mounting pitch
- (4) Mounting restrictions (angling, etc.)

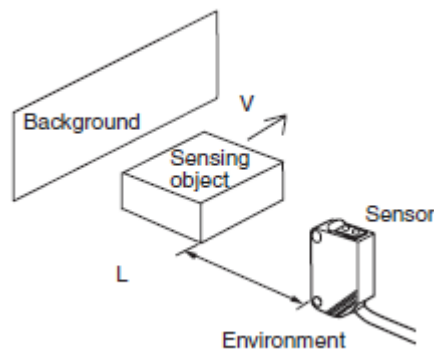
Background

Background

- (1) Color
- (2) Material (steel, SUS, wood, paper, etc.)
- (3) Surface conditions (textured, glossy, etc.)

Environment

- (1) Ambient temperature
- (2) Presence of splashing water, oil, or chemicals
- (3) Others



(3) Classification by Configuration

Photoelectric Sensors are generally comprised of an Emitter, Receiver, Amplifier, Controller, and Power Supply. They are classified as shown below according to how the components are configured.

1. Sensors with Separate Amplifiers

Through-beam Sensors have a separate Emitter and Receiver while Reflective Sensors have an integrated Emitter and Receiver. The Amplifier and Controller are housed in a single Amplifier Unit.

Features

Compact size because the integrated Emitter-Receiver is comprised simply of an Emitter, Receiver, and optical system.

Sensitivity can be adjusted remotely if the Emitter and Receiver are installed in a narrow space.

The signal wire from the Amplifier Unit to the Emitter and Receiver is susceptible to noise.

2. Built-in Amplifier Sensors

Everything except the power supply is integrated in these Sensors. (Through-beam Sensors are divided into the Emitter comprised solely of the Emitter and the Receiver comprised of the Receiver, Amplifier, and Controller.) The power supply is a standalone unit.

Features

The Receiver, Amplifier, and Controller are integrated to eliminate the need for weak signal wiring. This makes the Sensor less susceptible to noise.

Requires less wiring than Sensors with separate Amplifiers.

Although these Sensors are generally larger than those with separate Amplifiers, those with non-adjustable sensitivity are just as small.

3. Sensors with Built-in Power Supplies

The Power Supply, Emitter, and Receiver are all installed in the same housing with these Sensors.

Features

Sensors can be connected directly to a commercial power supply to provide a large control output directly from the Receiver.

These Sensors are much larger than those with other configurations because the Emitter and Receiver contain additional components, such as power supply transformers.

4. Area Sensors

An Area Sensor is a Through-beam Sensor which consists of a pair of Emitter and Receiver with multiple beams. Select the sensing width of the Sensor to fit the application.

Features

Area Sensors can sense wide areas.

These Sensors are ideal for picking systems for small parts.