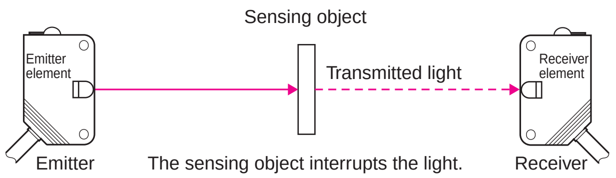
Overview

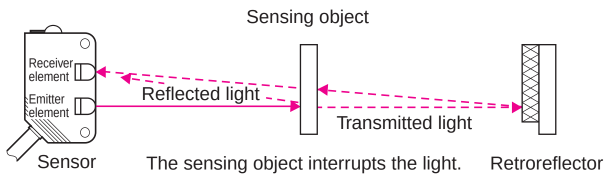
What Are Photoelectric Sensors?

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 colors).
Photoelectric Sensors are classified as shown in the figure below. (See *Classification* on page 5 for details.)

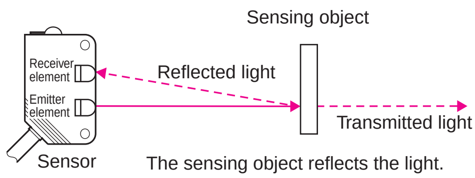
Through-beam Sensors



Retro-reflective Sensors



Diffuse-reflective Sensors



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) Color Identification
The rate at which an object reflects or absorbs light depends on both the wavelength of the emitted light and the color of the object. This property can be used to detect colors.

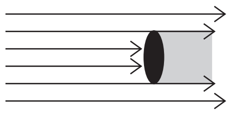
(7) Easy Adjustment
Positioning the beam on an object is simple with models that emit visible light because the beam is visible.

Operating Principles

(1) Properties of Light

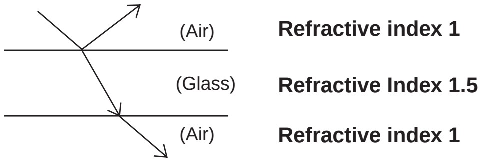
Rectilinear Propagation

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.



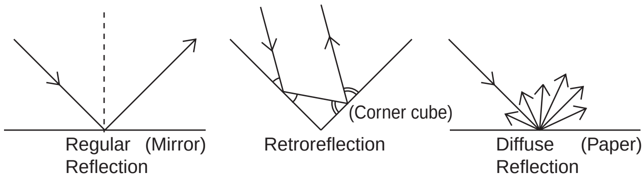
Refraction

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



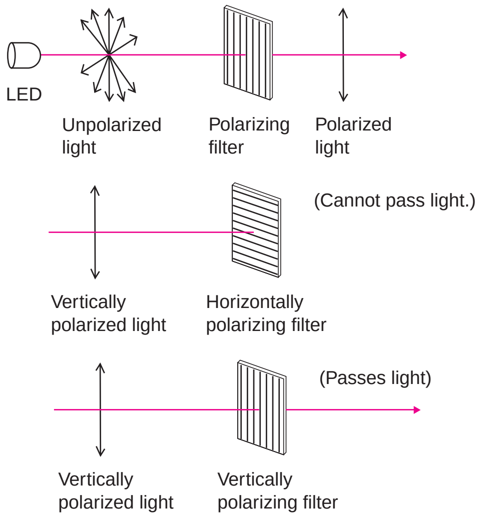
Reflection (Regular Reflection, Retroreflection, Diffuse Reflection)

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 (see page 15) and the Mutual Interference Protection Filter accessory for Through-beam Sensors operate on this principle.

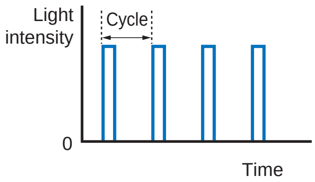


(2) Light Sources

Light Generation

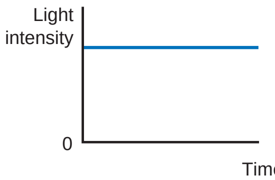
<Pulse Modulated light>

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.

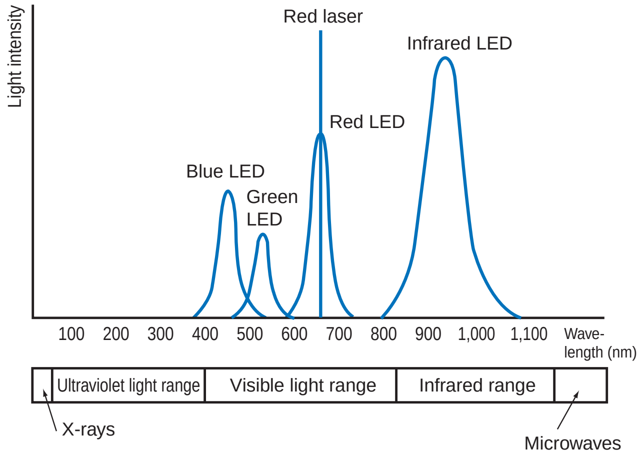


<Non-modulated Light>

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.



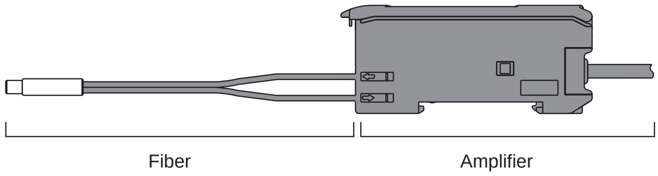
Light Source Color and Type



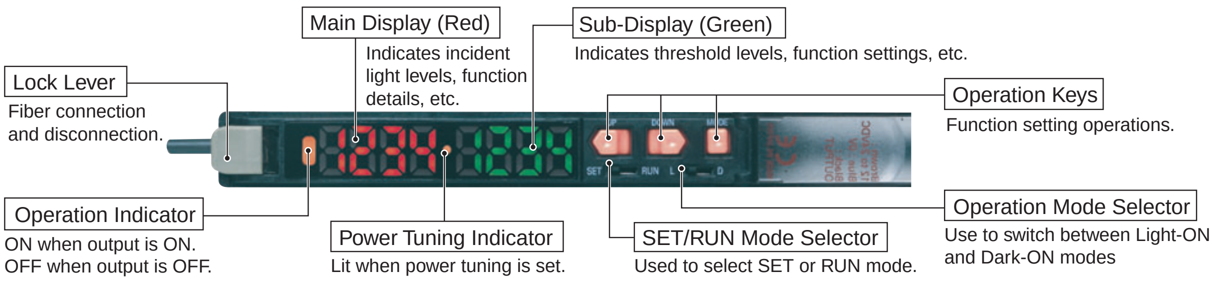
(3) Optical Fiber Sensors

Structure

With no electrical components in the sensing section (fiber), the Optical Fiber Sensor is highly resistant to noise and other environmental influences.

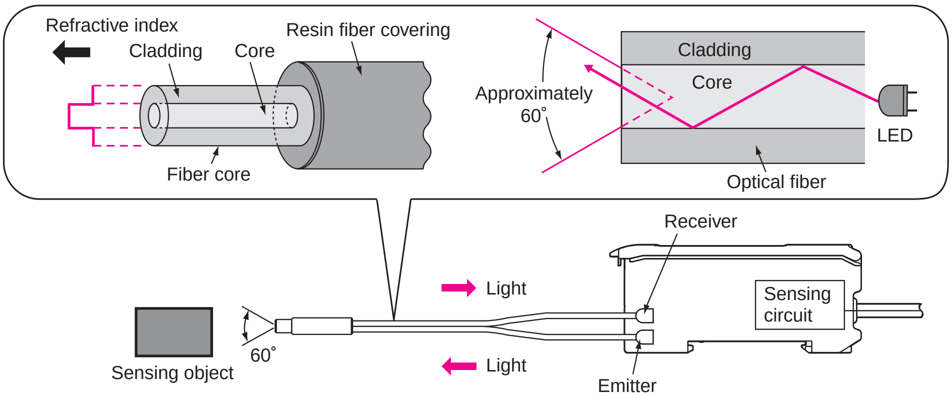


E3X-DA-S Digital Amplifier

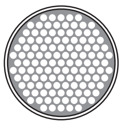
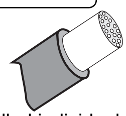
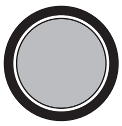
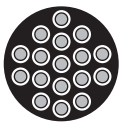
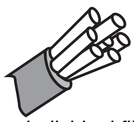


Detection Principles

Optical fiber is comprised of a central core with a high refractive index surrounded by cladding with a low refractive index. When light enters the core, repetitive total internal reflection at the boundary of the less refractive cladding guides the light down the optical fiber. The angle of the light traveling through the optical fiber increases to about 60° by the time the light exits the fiber and strikes a sensing object.

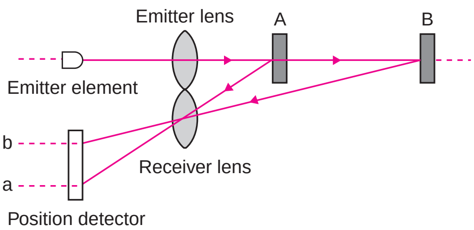


Optical Fiber Types and Characteristics

Cross section	Structure	Characteristics	Effective applications	Typical models
Flexible type (Multi-core) 	**New standard**  (Bundled individual fibers)	• Bending does not almost affect light intensity. • Allowable bend radius:1 mm	Compared to conventional Fibers: • As easy to install as soft electrical wiring. • Never have to worry about the bending radius. • Touching fibers does not affect light intensity.	E32-T11R E32-D11R
Standard type (single core) 		• Efficient light transmission at relatively long sensing distances • Allowable bend radius: 10 or 25 mm		E32-TC200 E32-DC200
Robot type (bundled) 	 (Loose individual fibers)	• Excellent bending-resistance characteristics Repeated bending: 1,000,000 times min. (typical example) • Allowable bending radius: 4 mm	• Resists damage when attached to moving parts, such as robot hands.	E32-T11 E32-D11

(4) 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.



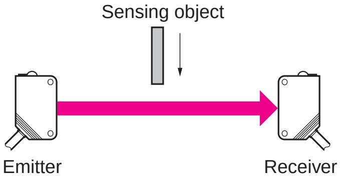
Classification

(1) Classification by Sensing Method

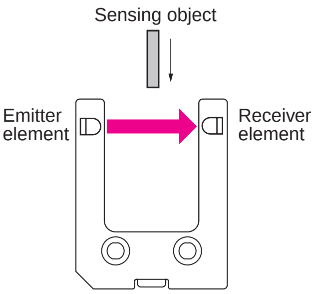
1) Through-beam Sensors

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.



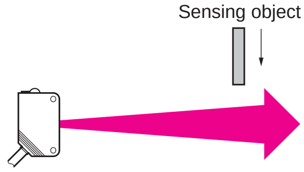
Features

- 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.



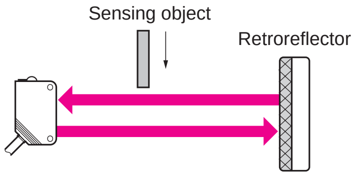
Features

- Sensing distance ranging from several centimeters to several meters.
- Easy mounting adjustment.
- The intensity of reflected light and operating stability 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.



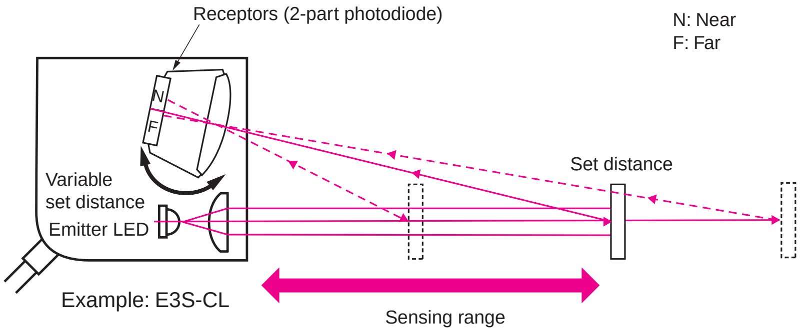
Features

- 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.

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.

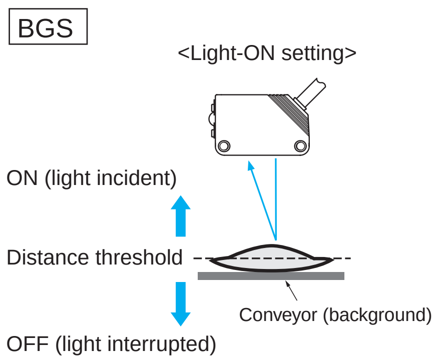


Features of Distance-settable Sensors

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

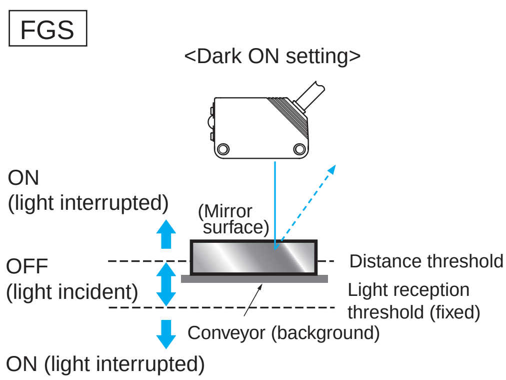
BGS (Background Suppression) and FGS (Foreground Suppression)

When using the E3Z-LS61, E3Z-LS66, E3Z-LS81, or E3Z-LS86, select the BGS or FGS function to detect objects on a conveyor belt.
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

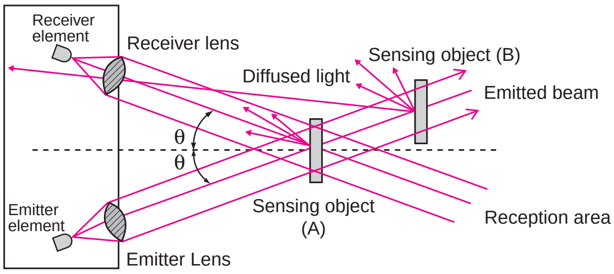
- Small differences in height can be detected (BGS and FGS).
- The effects of sensing object color are minimized (BGS and FGS).
- The effects of background objects are minimized (BGS).
- Sensing object irregularities may affect operation (BGS and FGS).



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 Emitter and Receiver are installed to receive only regular-reflection light, 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.)

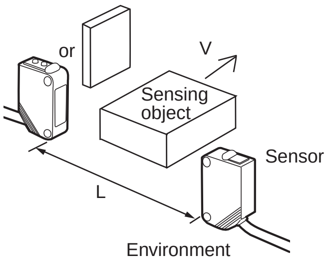
Sensor

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

Retro-reflective Sensors



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

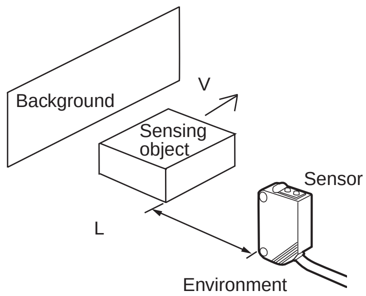
1. Sensing distance (distance to the workpiece) (L)
2. Restrictions on size and shape
3. Need for side-by-side mounting
   a) No. of units
   b) Mounting pitch
4. Mounting restrictions (angling, etc.)

Background

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.
- Typical Models (Amplifier Unit): E3C-LDA and E3C

2) Sensors with Built-in Amplifiers

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.
- Typical Models: E3Z, E3T, and E3S-C

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.
- Typical Models: E3G, E3JK, and E3JM

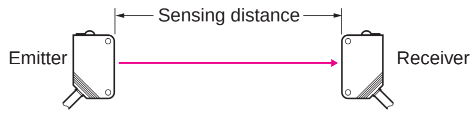
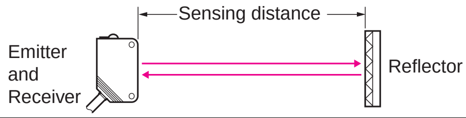
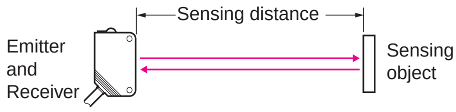
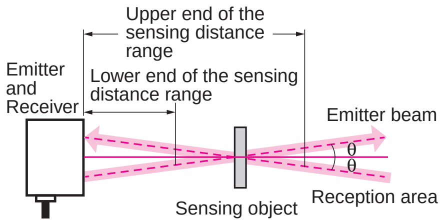
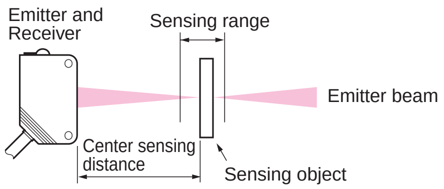
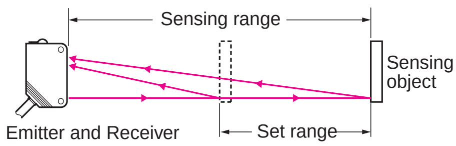
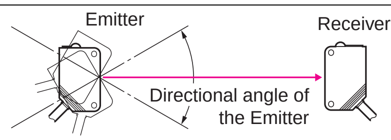
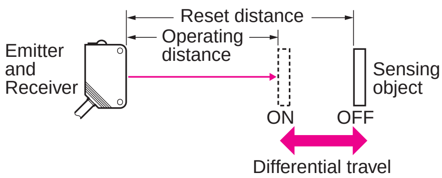
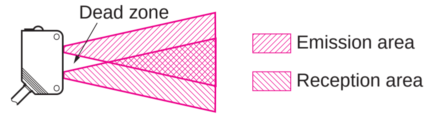
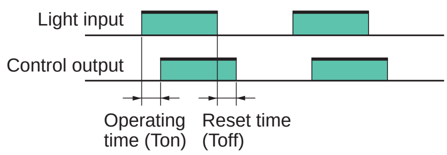
4) Optical Fiber Sensors

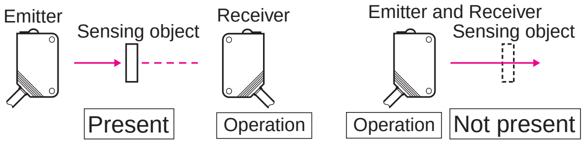
The Emitter and Receiver are connected by optical fiber. These Sensors are comprised of a Fiber Unit and an Amplifier Unit, but the OMRON product line does not include an Amplifier Unit with a built-in power supply.

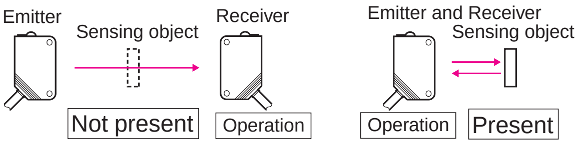
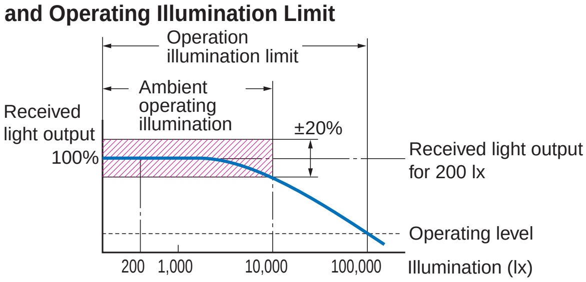
Features

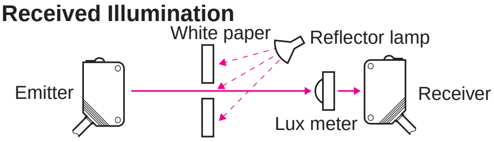
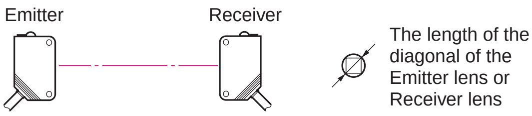
- Simply add a Fiber Head (end section) to make a Through-beam or Reflective Sensor.
- Ideally suited to detecting very small objects.
- Fiber Units are not susceptible to noise.
- Typical Models (Amplifier Unit): E3X-HD, E3X-SD, and E3X-DA-S

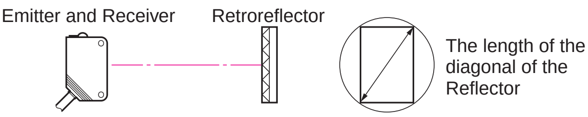
Explanation of Terms

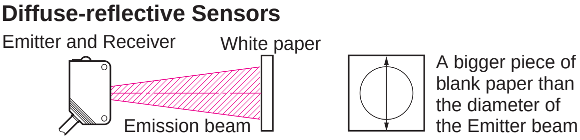
<table>
<tr><th colspan="2">Item</th><th>Explanatory diagram</th><th>Meaning</th></tr>
<tr><td rowspan="5">Sensing distance</td><td>Through-beam Sensors</td><td>
</td><td rowspan="2">The maximum sensing distance that can be set with stability for Through-beam and Retro-reflective Sensors, taking into account product deviations and temperature fluctuations. Actual distances under standard conditions will be longer than the rated sensing distances for both types of Sensor.</td></tr>
<tr><td>Retro-reflective Sensors</td><td>
</td></tr>
<tr><td>Diffuse-reflective Sensors</td><td>
</td><td>The maximum sensing distance that can be set with stability for the Diffuse-reflective Sensors, taking into account product deviations and temperature fluctuations, using the standard sensing object (white paper). Actual distances under standard conditions will be longer than the rated sensing distance.</td></tr>
<tr><td>Limited-reflective Sensors</td><td>
</td><td>As shown in the diagram at left, the optical system for the Limited-reflective Sensors is designed so that the Emitter axis and the Receiver axis intersect at the surface of the detected object at an angle θ.
With this optical system, the distance range in which regular-reflective light from the object can be detected consistently is the sensing distance. As such, the sensing distance can range from 10 to 35 mm depending on the upper and lower limits. (See page 7.)</td></tr>
<tr><td>Mark Sensors (Contrast scanner)</td><td>
</td><td>As shown in the diagram of the optical system at the left, a coaxial optical system is used that contains both an emitter and a receiver in one lens. This optical system provides excellent stability against fluctuations in the distance between the lens and the sensing object (i.e., marks). (With some previous models, the emitter lens and receiver lens are separated.)
The sensing distance is specified as the position where the spot is smallest (i.e., the center sensing distance) and the possible sensing range before and after that position.</td></tr>
<tr><td>Set range/ Sensing range</td><td>Distance-settable Sensors</td><td>
</td><td>Limits can be set on the sensing position of objects with Distance-settable Sensors. The range that can be set for a standard sensing object (white paper) is called the "set range." The range with the set position limits where a sensing object can be detected is called the "sensing range." The sensing range depends on the sensing mode that is selected. The BGS mode is used when the sensing object is on the Sensor side of the set position and the FGS mode is used when the sensing object is on the far side of the set position. (See page 6.)</td></tr>
<tr><td colspan="2">Directional angle</td><td>
</td><td>Through-beam Sensors, Retro-reflective Sensors
The angle where operation as a Photoelectric Sensor is possible.</td></tr>
<tr><td colspan="2">Differential travel</td><td>
</td><td>Diffuse-reflective and Distance-settable Sensors
The difference between the operating distance and the reset distance.
Generally expressed in catalogs as a percentage of the rated sensing distance.</td></tr>
<tr><td colspan="2">Dead zone</td><td>Example for Diffuse-reflective Sensor

</td><td>The dead zone outside of the emission and reception areas near the lens surface in Mark Sensors, Distance-settable Sensors, Limited-reflective Sensors, Diffuse-reflective Sensors, and Retro-reflective Sensors. Detection is not possible in this area.</td></tr>
<tr><td colspan="2">Response time</td><td>
</td><td>The delay time from when the light input turns ON or OFF until the control output operates or resets. In general for Photoelectric Sensors, the operating time (Ton) ≈ reset time (Toff).</td></tr>
</table>

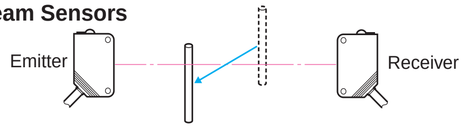
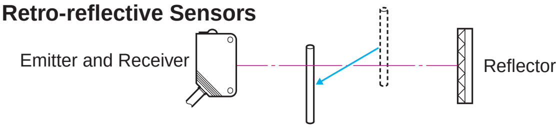
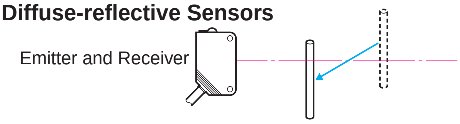
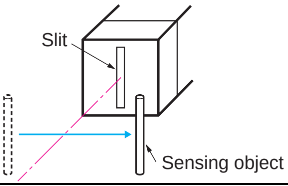
<table>
<tr><th>Item</th><th>Explanatory diagram</th><th>Meaning</th></tr>
<tr><td>Dark-ON operation
(DARK ON)</td><td>Through-beam, Retro-reflective Sensors / Diffuse-reflective Sensors

</td><td rowspan="2">The "Dark-ON" operating mode is when a Through-beam Sensor produces an output when the light entering the Receiver is interrupted or decreases.

The "Light-ON" operating mode is when a Diffuse-reflective Sensor produces an output when the light entering the Receiver increases.</td></tr>
<tr><td>Light-on operation
(LIGHT ON)</td><td>Through-beam, Retro-reflective Sensors / Diffuse-reflective Sensors

</td></tr>
<tr><td>Ambient operating illumination</td><td>Difference between Ambient Operating Illumination and Operating Illumination Limit


Received Illumination

</td><td>The ambient operating illumination is expressed in terms of the Receiver surface illuminance and is defined as the illuminance when there is a ±20% change with respect to the value at a light reception output of 200 lx. This is not sufficient to cause malfunction at the operating illuminance limit.</td></tr>
<tr><td>Standard sensing object</td><td>Through-beam Sensors


Retro-reflective Sensors


Diffuse-reflective Sensors

</td><td>The standard sensing object for both Through-beam Sensors and Retro-reflective Sensors is an opaque rod with a diameter larger than the length of a diagonal line of the optical system. In general, the diameter of the standard sensing object is the length of the diagonal line of the Emitter/Receiver lens for Through-beam Sensors, and the length of a diagonal line of the Reflector for Retro-reflective Sensors.
Size of Standard Sensing Object Using Reflector
<table>
<tr><th>Reflector models</th><th>Diagonal line of optical system</th><th>Sensing object</th></tr>
<tr><td>E39-R1/R1S/R1K</td><td>72.2 mm</td><td>75-mm dia.</td></tr>
<tr><td>E39-R2</td><td>100.58 mm</td><td>105-mm dia.</td></tr>
<tr><td>E39-R3</td><td>41.44 mm</td><td>45-mm dia.</td></tr>
<tr><td>E39-R4</td><td>26.77 mm</td><td>30-mm dia.</td></tr>
<tr><td>E39-R6</td><td>56.57 mm</td><td>60-mm dia.</td></tr>
<tr><td>E39-R9</td><td>43.7 mm</td><td>45-mm dia.</td></tr>
<tr><td>E39-R10</td><td>66.47 mm</td><td>70-mm dia.</td></tr>
<tr><td>E39-RS1</td><td>36.4 mm</td><td>40-mm dia.</td></tr>
<tr><td>E39-RS2</td><td>53.15 mm</td><td>55-mm dia.</td></tr>
<tr><td>E39-RS3</td><td>106.3 mm</td><td>110-mm dia.</td></tr>
<tr><td>E39-R37</td><td>13.4 mm</td><td>15-mm dia.</td></tr>
</table>For Diffuse-reflective Sensors, the standard sensing object is a sheet of white paper larger than the diameter of the emitted beam.</td></tr>
</table>

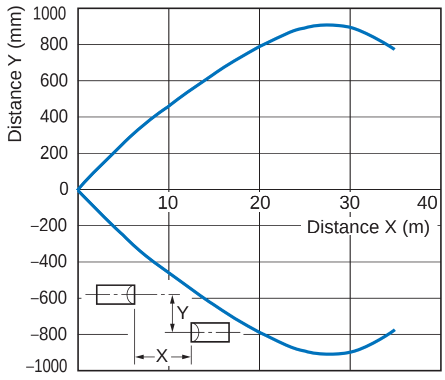
Item	Explanatory diagram	Meaning
Minimum sensing object	**Through-beam Sensors**  **Retro-reflective Sensors**  **Diffuse-reflective Sensors**  	Typical examples are given of the smallest object that can be detected using Through-beam and Retro-reflective Sensors with the sensitivity correctly adjusted to the light-ON operation level at the rated sensing distance. For Diffuse-reflective Sensors, typical examples are given of the smallest objects that can be detected with the sensitivity set to the highest level.
Minimum sensing object with slit attached	 	Through-beam Sensors Typical examples are given of the smallest object that can be detected using Through-beam Sensors with a Slit attached to both the Emitter and the Receiver as shown in the figure. The sensitivity is correctly adjusted to the Light-ON operating level at the rated sensing distance and the sensing object is moved along the length and parallel to the slit.

Interpreting Engineering Data

Through-beam Sensors and Retro-reflective Sensors

Parallel Operating Range

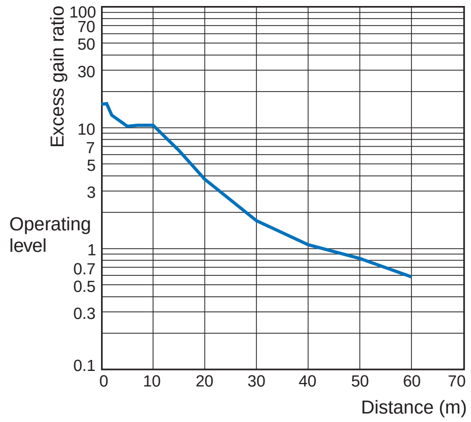
E3Z-T□1(T□6) Characteristics



- Through-beam Sensors: Indicates the sensing position limit for the Receiver with the Emitter at a fixed position.
- Retro-reflective Sensors: Indicates the sensing position limit for the Retroreflector when the Sensor is at a fixed position.
- Sensitivity is set to the maximum value in both cases and the area between the top and bottom lines is the detectable area.
- An area 1.5 times the area shown in the diagram is required to prevent mutual interference with more than one Through-beam Sensor installed.

Excess Gain Ratio vs. Set Distance

E3Z-T□1(T□6) Characteristics

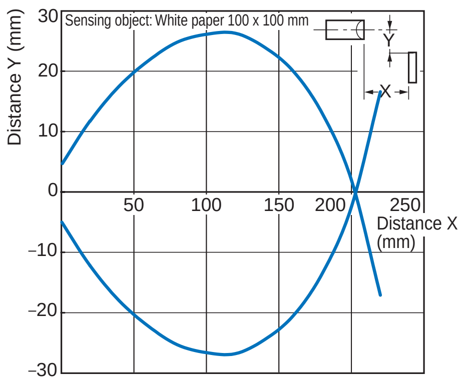


- The excess gain ratio shown here is the value with the sensitivity set to the maximum value.
- The rated sensing distance above is for a 15-m model. The graph shows that the excess gain ratio is approximately 6 at the rated sensing distance.

Diffuse-reflective Sensors

Operating Range

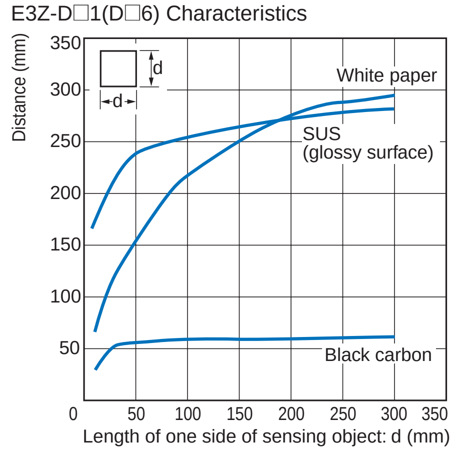
E3Z-D□1(D□6) Characteristics



- Indicates the sensing start position when a standard sensing object is moved in the Y direction (vertically along the optical axis). The bottom curve in the diagram is for when the sensing object is moved from the bottom.

Size of Sensing Object vs. Sensing Distance

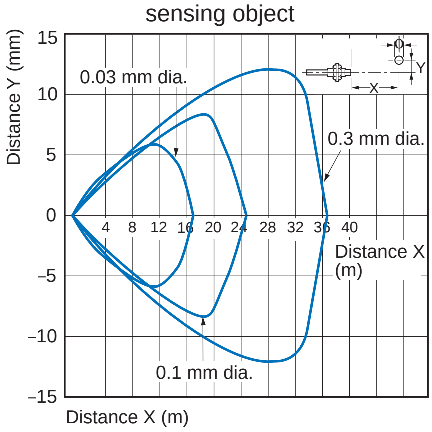
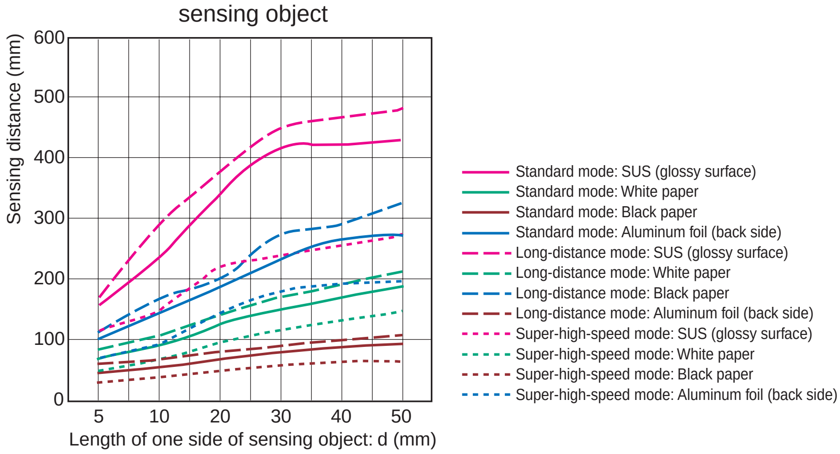
E3Z-D□1(D□6) Characteristics



- Indicates how the sensing distance varies with the size and surface color of the sensing object.

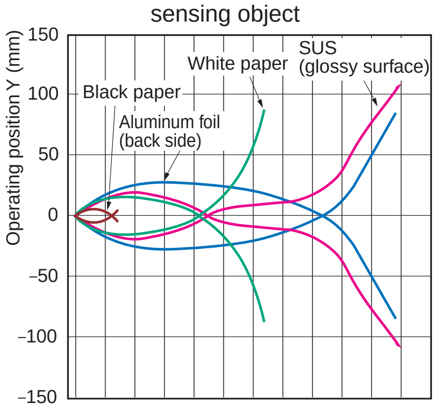
Note: These values are for the standard sensing object. The operating area and sensing distance will change for a different object.

Diffuse-reflective and Retro-reflective Sensors

Size of Sensing Object vs. Operating Range	Object Surface Color vs. Sensing Distance
The width and the operating range of E3X-DA-S+E32-DC200 (example) sensing object	The surface color and the sensing distance of E3X-DA-S+E32-DC200 (example) sensing object
	
• Indicates how the operating range of the Sensor varies with the width of the sensing object. • Each enclosed area indicates the operating area of the respective sensing object width.	• When using a Reflective Photoelectric Sensor, the surface color and gloss of the object will affect the sensing distance and the operating area. • Indicates that the sensing distance lengthens as the reflectance of the object surface increases.

Surface Color of Object, Gloss, and Operating Range

The surface color and the operating range of E3X-DA-S+E32-DC200 (example) sensing object



Standard mode + Maximum sensitivity

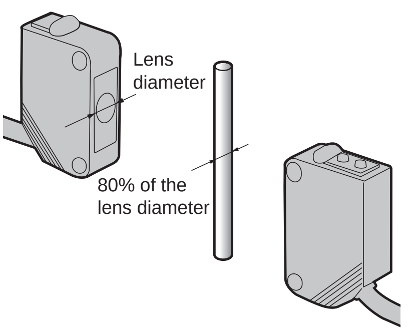
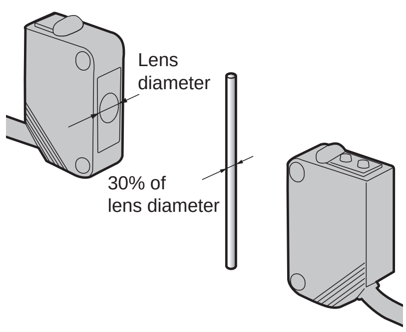
- Indicates that a black object with the lowest reflectance has the smallest operating (sensing) area.
- SUS and aluminum foil are glossy and will enable a longer sensing distance. The reflection of the light by the surface, however, will only be regular reflection, not diffuse reflection, and thus the operating area will be smaller than with white paper.

Application and Data

(1) Relationship of Lens Diameter and Sensitivity to the Smallest Detectable Object

- With a Through-beam Sensor, the lens diameter determines the size of the smallest object that can be detected.
- With a Through-beam Sensor, a small object can be more easily detected midway between the Emitter and the Receiver that it can be off center between the Emitter and Receiver.
- As a rule of thumb, an object 30% to 80% of the lens diameter can be detected by varying the sensitivity level.
- Check the ***Ratings and Specifications*** of the Sensor for details.

The size given for the smallest object that can be detected with a Reflective Photoelectric Sensor is the value for detection with no objects in the background and the sensitivity set to the maximum value.

Maximum sensitivity	Adjusted sensitivity
	
Detects objects 80% of the lens diameter.	Detects objects up to 30% of the lens diameter.

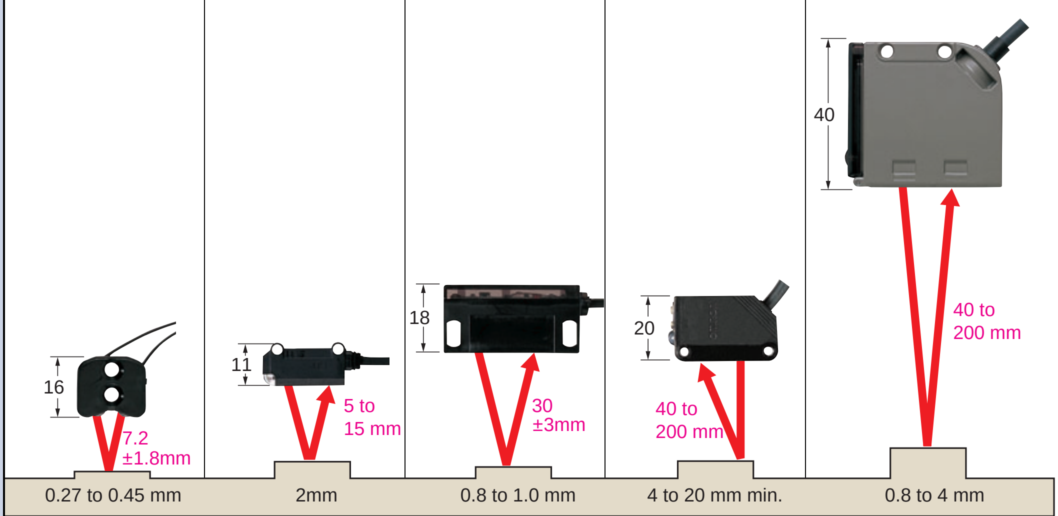
(2) Detecting Height Differences

Selecting Sensors Based on Detectable Height Differences and Set Distances (Typical Examples)

Sensing distance

Difference in height

Appearance



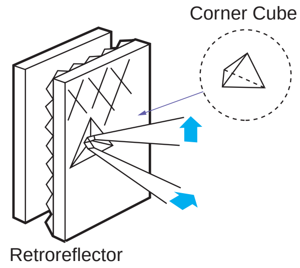
Features	Optical Fiber Sensors	• Built-in Amplifier Sensors • Microsensors	Separate Amplifier Sensors	Built-in Amplifier Sensors	Built-in Amplifier Sensors
Model	E32-L25L	E3T-SL1□	E3C-LS3R	E3Z-LS	E3S-CL1

(3) MSR (Mirror Surface Rejection) Function

[Principles]

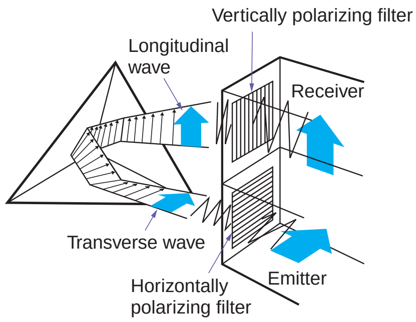
This function and structure uses the characteristics of the Retroreflector and the polarizing filters built into the Retro-reflective Sensors to receive only the light reflected from the Retroreflector.

- The waveform of the light transmitted through a polarizing filter in the Emitter changes to polarization in a horizontal orientation.
- The orientation of the light reflected from the triangular pyramids of the Retroreflector changes from horizontal to vertical.
- This reflected light passes through a polarizing filter in the Receiver to arrive at the Receiver.



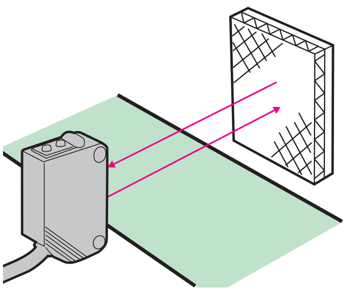
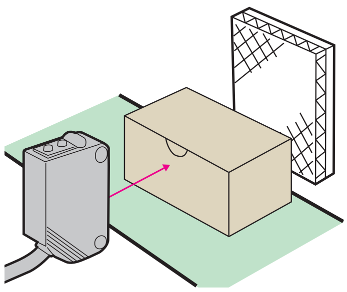
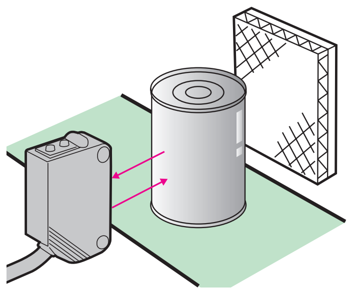
[Purpose]

This method enables stable detection of objects with a mirror-like surface.
Light reflected from these types of objects cannot pass through the polarizing filter on the Receiver because the orientation of polarization is kept horizontal.



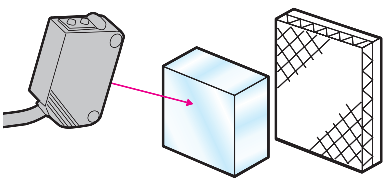
[Examples]

A sensing object with a rough, matte surface (example (2)) can be detected even without the MSR function. If the sensing object has a smooth, glossy surface on the other hand (example (3)), it cannot be detected with any kind of consistency without the MSR function.

(1) No Object	(2) Non-glossy Object	(3) Object with a Smooth, Glossy Surface (Example: battery, can, etc.)
The light from the Emitter hits the Reflector and returns to the Receiver.	Light from the Emitter is intercepted by the object, does not reach the Reflector, and thus does not return to the Receiver.	Light from the Emitter is reflected by the object and returns to the Receiver.
		

[Caution]

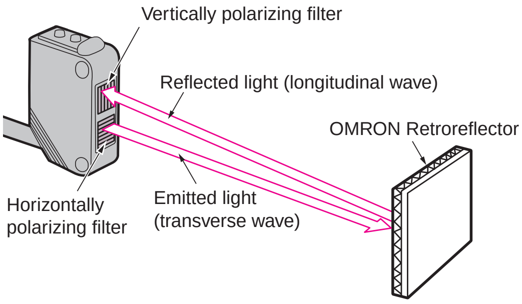
Stable operation is often impossible when detecting objects with high gloss or objects covered with glossy film. If this occurs, install the Sensor so that it is at an angle off perpendicular to the sensing object.

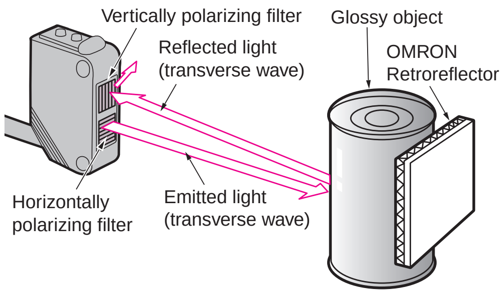


Retro-reflective Sensors with MSR function

Retro-reflective Sensors with MSR function	
Classification by Configuration	**Model**
Optical Fiber Sensors	E32-R21, E32-R16
Built-in Amplifier Sensors	E3Z-R61/R66/R81/R86
	E3ZM-R61/R66/R81/R86/B61/B66/B81/B86
	E3ZM-CR61(-M1TJ)/CR81(-M1TJ)
	E3S-CR11(-M1J)/CR61(-M1J)
Separate Amplifier Sensors	E3C-LR11/LR12
Built-in Power Supply Sensors	E3JM-R4□4(T), E3JK-R2M□/R2S3

Note: When using a Sensor with the MSR function, be sure to use an OMRON Reflector





Retro-reflective Sensors without MSR Function

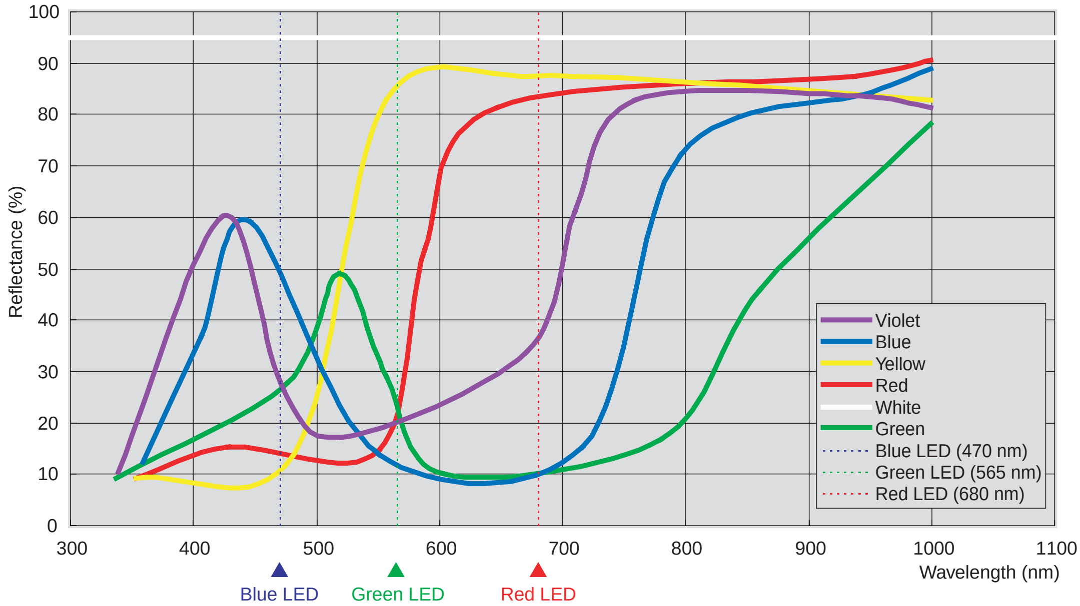
When detecting a glossy object using a Retro-reflective Sensor without the MSR function, mount the Sensor diagonally to the object so that reflection is not received directly from the front surface.

Retro-reflective Sensors without MSR Function	
Classification by Configuration	**Model**
Transparent Object Sensors	E3Z-B61/B62/B66/B67/B81/B82/B86/B87

(4) Surface Color and Light Source Reflectance

Surface Color Reflectance

Reflectance of Various Colors at Different Wavelengths of Light



Identifiable Color Marks

Sensor Light Color : Blue

	White	Red	Yellow	Green	Blue	Violet	Black
White		5	5	3		3	8
Red	5				3	2	
Yellow	5			2	4	2	
Green	3		2		2		3
Blue		3	4	2			6
Violet	3	2	2				4
Black	8			3	6	4	

Sensor Light Color : Green

	White	Red	Yellow	Green	Blue	Violet	Black
White		8			3	5	10
Red	8		5	5	3		
Yellow		5				3	6
Green		5				3	6
Blue	3	3					4
Violet	5		3	3			3
Black	10		6	6	4	3	

Sensor Light Color : Red

	White	Red	Yellow	Green	Blue	Violet	Black
White				5	6	3	9
Red				4	4	2	7
Yellow				5	5	3	8
Green	5	4	5			2	
Blue	6	4	5			2	
Violet	3	2	3	2	2		4
Black	9	7	8			4	

The numbers express the degree of margin (percentage of received light for typical examples).
Models with an RGB light source support all combinations.

Sensor light color	Product classification	Model
Red light source ●	Optical Fiber Sensors	E3X-HD
		E3X-SD
		E3X-NA
		E3X-DA-S
		E3X-MDA
	Separate Amplifier Sensors	E3C-VS3R E3C-VM35R E3C-VS7R
Blue light source ●	Optical Fiber Sensors	E3X-DAB-S
Green light source ●	Optical Fiber Sensors	E3X-DAG-S
		E3X-NAG
	Separate Amplifier Sensors	E3C-VS1G
White light source ●●●	Optical Fiber Sensors	E3X-DAC-S

(5) Self-diagnosis Functions

The self-diagnosis function checks for margin with respect to environmental changes after installation, especially temperature, and informs the operator of the result through indicators and outputs. This function is an effective means of early detection of product failure, optical axis displacement, and accumulation of dirt on the lens over time.

[Principles]

These functions alert the operator when the Sensor changes from a stable state to an unstable state. The functions can be broadly classified into display functions and output functions.

Display function

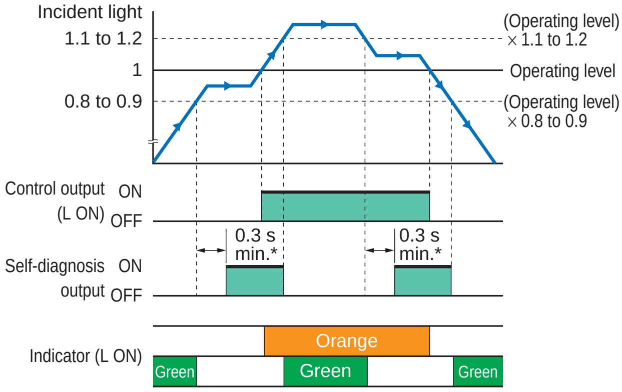
- Stability Indicator (green LED)
  The amount of margin with respect to environmental changes (temperature, voltage, dust, etc.) after installation is monitored by the self-diagnosis function and indicated by an indicator. (Illuminates steadily when there are no problems.)
- Operation Indicator (Orange LED)
  Indicates the output status.

Output function

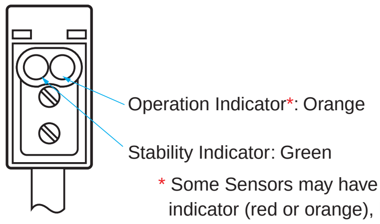
The margin is indicated by an indicator light, and the state is output to alert the operator.

[Purpose]

Self-diagnosis functions are effective in maintaining stable operation, alerting the operator to displacement of the optical axis, dirt on the lens (Sensor surface), the influence from the floor and background, external noise, and other potential failures of the Sensor.

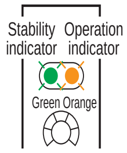


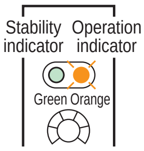
* If the moving speed of sensing object is slow, the Sensor may output a self-diagnosis output. When using the Photoelectric sensor, please install an ON-delay timer circuit etc..

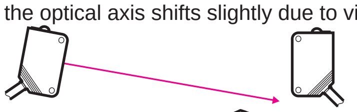
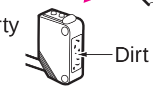
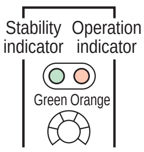


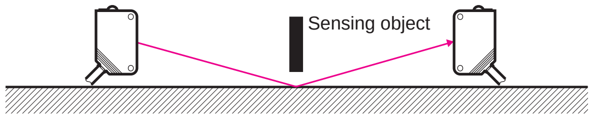
* Some Sensors may have an incident light indicator (red or orange), but it depends on the model.

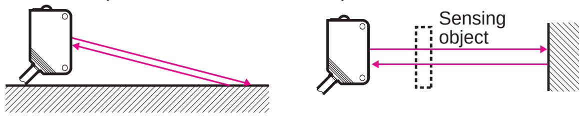
Example: Light-ON Operation

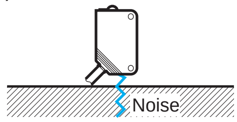
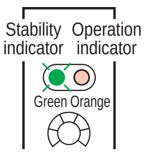
<table>
<tr><th>Indicator state</th><th>Light-ON/Dark-ON indicated by the orange indicator</th><th>Degree of margin with respect to temperature changes indicated by the green indicator</th><th>Self-diagnosis output</th><th>Example of diagnosed condition</th></tr>
<tr><td>

Operating level x 1.1 to 1.2</td><td rowspan="2">Light Incident
orange indicator ON</td><td>Stable use is possible.
(Margin of 10% to 20% or higher)
(Stability indicator: ON)</td><td>---</td><td>---</td></tr>
<tr><td>

Operating level</td><td rowspan="2">The margin is not sufficient.
(Green indicator: OFF)</td><td rowspan="2">When this state continues for a certain period of time, an output alerts the operator.</td><td>• Example: Incident light becomes unstable.
(1) When the optical axis shifts slightly due to vibration.

(2) When the lens became dirty from adhesion of dust.

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

Operating level x 0.8 to 0.9</td><td rowspan="2">Light Interrupted
orange indicator OFF</td><td>• Example: Operation is unstable when light is interrupted.
(1) Light has leaked around the sensing object (Through-beam Sensors or Retro-reflective Sensors).


(2) Reflected light from the floor or the background has been received (Diffuse-reflective Sensor).


(3) External noise has influenced operation.

</td></tr>
<tr><td>
</td><td>Stable use is possible.
(Margin of 10% to 20% or higher)
(Stability indicator: ON)</td><td>---</td><td>---</td></tr>
</table>

<Applicable Models>

<table>
<tr><th rowspan="2">Classification by Configuration</th><th rowspan="2">Models</th><th colspan="2">Self-diagnosis function</th></tr>
<tr><th>Display function</th><th>Output function</th></tr>
<tr><td rowspan="3">Optical Fiber Sensors</td><td>E3X-DA-S</td><td>Digital display</td><td>●</td></tr>
<tr><td>E3X-MDA</td><td>Digital display</td><td>---</td></tr>
<tr><td>E3X-NA</td><td>●</td><td>---</td></tr>
<tr><td rowspan="2">Separate Amplifier Sensors</td><td>E3C-LDA</td><td>Digital display</td><td>●</td></tr>
<tr><td>E3C</td><td>●</td><td>●(E3C-JC4P)</td></tr>
<tr><td rowspan="5">Built-in Amplifier Sensors</td><td>E3Z</td><td>●</td><td>---</td></tr>
<tr><td>E3ZM(-C)</td><td>●</td><td>---</td></tr>
<tr><td>E3T</td><td>●</td><td>---</td></tr>
<tr><td>E3S-C</td><td>●</td><td>---</td></tr>
<tr><td>E3S-CL</td><td>●</td><td>---</td></tr>
</table>

General Precautions

For precautions on individual products, refer to *Safety Precautions* in individual product information.

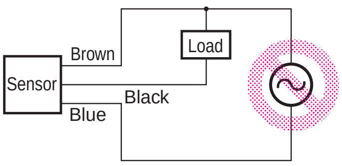
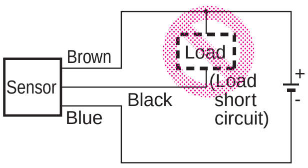
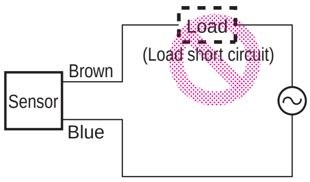
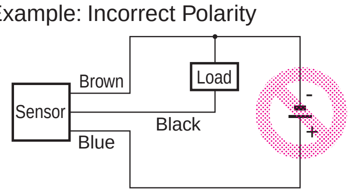
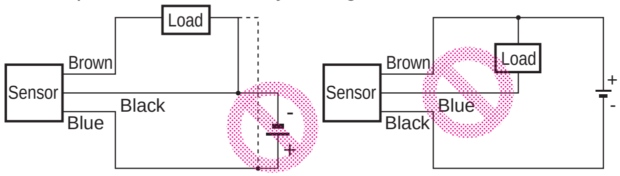
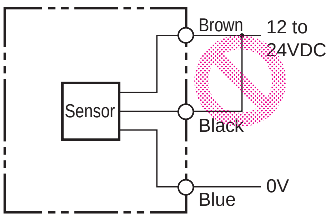
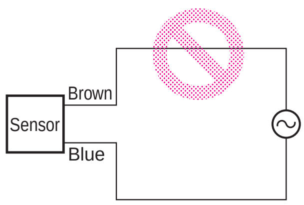
⚠ WARNING

These Sensors cannot be used in safety devices for presses or other safety devices used to protect human life. These Sensors are designed for use in applications for sensing workpieces and workers that do not affect safety.

Precautions for Safe Use

To ensure safety, always observe the following precautions.

● **Wiring**

Item	Typical examples	
Power Supply Voltage Do not use a voltage in excess of the operating voltage range. Applying a voltage in excess of the operating voltage range, or applying AC power (100 VAC or greater) to a DC Sensor may cause explosion or burning.	• DC Three-wire NPN Output Sensors  	---
Load Short-circuiting Do not short-circuit the load. Doing so may cause explo-sion or burning.	• DC Three-wire NPN Output Sensor  	• AC Two-wire Sensors 
Incorrect Wiring Do not reverse the power supply polarity or otherwise wire incorrectly. Doing so may cause explosion or burning.	• DC Three-wire NPN Output Sensors Example: Incorrect Polarity  	• DC Three-wire NPN Output Sensors Example: Incorrect Polarity Wiring 
Connection without a load If the power supply is connected directly without a load, the internal elements may burst or burn. Be sure to insert a load when connecting the power supply.	• DC Three-wire NPN Output Sensors  	• AC 2-wire Sensors 

● **Operating Environment**

(1) Do not use a Sensor in an environment where there are explosive or inflammable gases.

(2) Do not use the Sensor in environments where the cables may become immersed in oil or other liquids or where liquids may penetrate the Sensor. Doing so may result in damage from burning and fire, particularly if the liquid is flammable.

Precautions for Correct Use

● Design

Power Reset Time

The Sensor will be ready to detect within approximately 100 ms after the power is turned ON.
If the Sensor and the load are connected to separate power supplies, turn ON the Sensor power before turning ON the load power. Any exceptions to this rule are indicated in *Safety Precautions* in individual product information.

Turning OFF Power

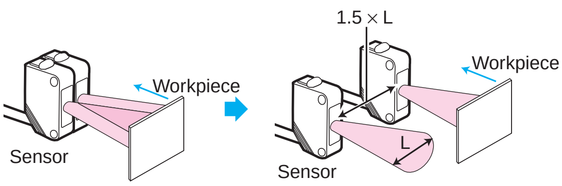
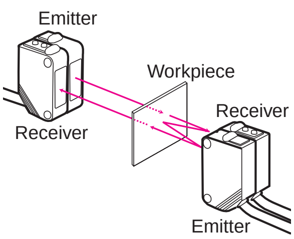
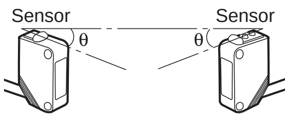
An output pulse may be generated when the power is turned OFF. It is recommended that the load or load line power be turned OFF before the Sensor power is turned OFF.

Power Supply Types

An unsmoothed full-wave or half-wave rectifying power supply cannot be used.

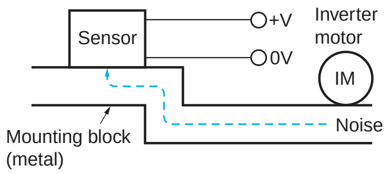
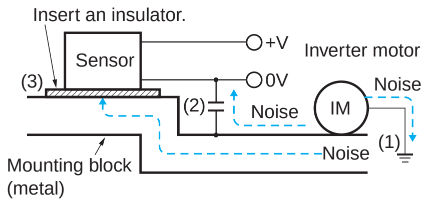
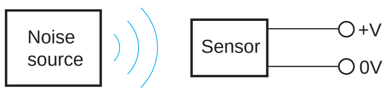
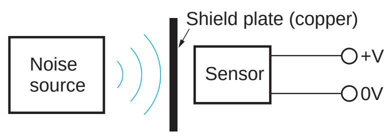
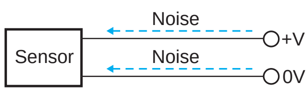
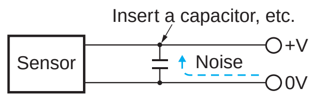
Mutual Interference

Mutual interference is a state where an output is unstable because the Sensors are affected by light from the adjacent Sensors.
The following measures can be taken to avoid mutual interference.

<table>
<tr><th>Counter-measure</th><th>Concept</th><th>Through-beam Sensors</th><th>Reflective Sensors</th></tr>
<tr><td>1</td><td>Use a Sensor with the interference prevention function.</td><td colspan="2">If Sensors are mounted in close proximity, use Sensors with the interference prevention function.
10 or fewer Sensors: E3X-HD, E3X-DA□-S, E3X-MDA, E3C-LDA Fiber Sensors
Performance, however, will depend on conditions. Refer to pages E3X-HD, E3X-DA-S/E3X-MDA and E3C-LDA.
5 or fewer Sensors: E3X-NA, E3X-SD Fiber Sensors
2 or fewer Sensors: E3T, E3Z, E3ZM, E3ZM-C, or E3S-C Built-in Amplifier Photoelectric Sensors (except Through-beam Sensors)
E3C Photoelectric Sensor with separate amplifier</td></tr>
<tr><td>2</td><td>Install an interference prevention filter.</td><td>A mutual interference prevention polarizing filter can be installed on only the E3Z-TA to allow close-proximity mounting of up to 2 Sensors.
Mutual Interference Prevention Polarizing Filter: E39-E11</td><td>---</td></tr>
<tr><td>3</td><td>Separate Sensors to distance where interference does not occur.</td><td>Check the parallel movement distance range in the catalog, verify the set distance between adjacent Sensors, and install the Sensors accordingly at a distance at least 1.5 times the parallel movement distance range.</td><td>If the workpieces move from far to near, chattering may occur in the vicinity of the operating point. For this type of application, separate the Sensors by at least 1.5 times the operating range.

</td></tr>
<tr><td>4</td><td>Alternate Emitters and Receivers.</td><td>Close mounting of Sensors is possible by alternating the Emitters with the Receivers in a zigzag fashion (up to two Sensors). However, if the workpieces are close to the Photoelectric Sensors, light from the adjacent Emitter may be received and cause the Sensor to change to the incident light state.

</td><td>---</td></tr>
<tr><td>5</td><td>Offset the optical axes.</td><td>If there is a possibility that light from another Sensor may enter the Receiver, change the position of the Emitter and Receiver, place a light barrier between the Sensors, or take other measures to prevent the light from entering the Receiver.
(Light may enter even if the Sensors are separated by more than the sensing distance.)</td><td>If Sensors are mounted in opposite each other, slant the Sensors as shown in the following diagram. (This is because the Sensors may affect each other and cause output chattering even if separated by more than the Sensor sensing distance.)

</td></tr>
<tr><td>6</td><td>Adjust the sensitivity.</td><td colspan="2">Lowering the sensitivity will generally help.</td></tr>
</table>

Noise

Countermeasures for noise depend on the path of noise entry, frequency components, and wave heights. Typical measures are as given in the following table.

Type of noise	Noise intrusion path and countermeasure	
	Before countermeasure	After countermeasure
Common mode noise (inverter noise) (Common noise applied between the mounting board and the +V and 0-V lines, respectively.)	Noise enters from the noise source through the frame (metal). 	(1) Ground the inverter motor (to 100 Ω or less) (2) Ground the noise source and the power supply (0-V side) through a capacitor (film capacitor, 0.22 μF, 630 V). (3) Insert an insulator (plastic, rubber, etc.) between the Sensor and the mounting plate (metal). 
Radiant noise (Ingress of high-frequency electromagnetic waves directly into Sensor, from power line, etc.)	Noise propagates through the air from the noise source and directly enters the Sensor. 	• Insert a shield (copper) plate between the Sensor and the noise source e.g., a switching power supply). • Separate the noise source and the Sensor to a distance where noise does not affect operation. 
Power line noise (Ingress of electromagnetic induction from high-voltage wires and switching noise from the switching power supply)	Noise enters from the power line. 	• Insert a capacitor (e.g., a film capacitor), noise filter (e.g., ferrite core or insulated transformer), or varistor in the power line. 

● Wiring

Cable

Unless otherwise indicated, the maximum length of cable extension is 100 m using wire that is 0.3 mm^2 or greater.
Exceptions are indicated in ***Safety Precautions*** in individual product information.

Cable Tensile Strength

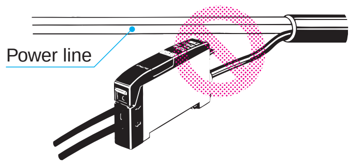
When wiring the cable, do not subject the cable to a tension greater than that indicated in the following table.

Cable diameter	Tensile strength
Less than 4 mm	30 N max.
4 mm or greater	50 N max.

Note: Do not subject a shielded cable or coaxial cable to tension.

Separation from High Voltage (Wiring Method)

Do not lay the cables for the Sensor together with high-voltage lines or power lines. Placing them in the same conduit or duct may cause damage or malfunction due to induction interference. As a general rule, wire the Sensor in a separate system, use an independent metal conduit, or use shielded cable.



Work Required for Unconnected Leads

Unused leads for self-diagnosis outputs or other special functions should be cut and wrapped with insulating tape to prevent contact with other terminals.

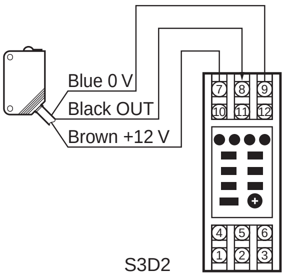
Power Supply

When using a commercially available switching regulator, ground the FG (frame ground) and G (ground) terminals.
If not grounded, switching noise in the power supply may cause malfunction.

Example of Connection with S3D2 Sensor Controller

DC Three-wire NPN Output Sensors

Reverse operation is possible using the signal input switch on the S3D2.



● Mounting

Attachment to Moving Parts

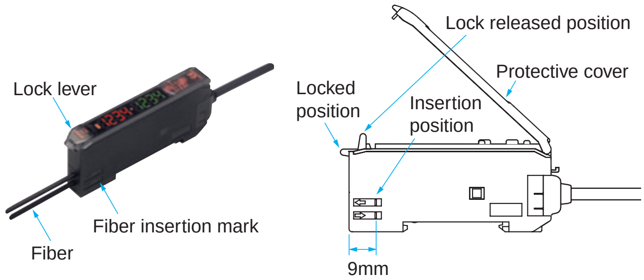
To mount the Photoelectric Sensor to a moving part, such as a robot hand, consider using a Sensors that uses a bending-resistant cable (robot cable).

Securing Fibers

The E3X Fiber Unit uses a one-touch locking mechanism. Use the following methods to attach and remove Fiber Units.

(1) Attaching Fibers

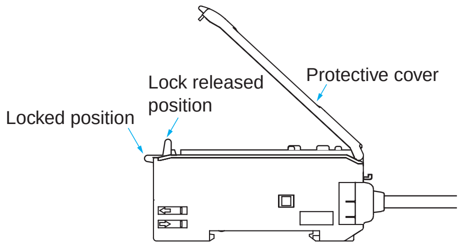
Open the protective cover, insert the fiber up to the insertion mark on the side of the Fiber Unit, and then lower the lock lever.



Note: If one of the fibers from the Fiber Unit has a white line, such as with a Coaxial Sensor, that fiber is for the Emitter. Insert it into the Emitter section. Refer to Dimensions for the Fiber Unit to see if there is an Emitter fiber.

(2) Removing Fibers

Open the protective cover, lift up the lock lever, and pull out the fibers.

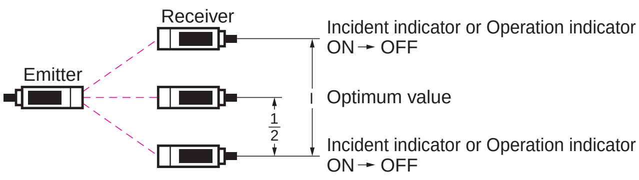


Note: 1. To maintain the fiber characteristics, make sure that the lock is released before removing the fibers.
2. Lock and unlock the fibers at an ambient temperature of −10 to 40°C.

● Adjustments

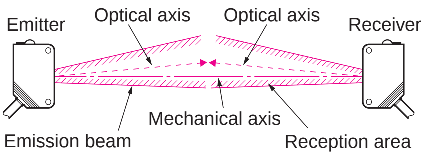
Optical Axis Adjustment

Move the Photoelectric Sensor both vertically and horizontally and set it in the center of the range in which the operation indicator is lit or not lit. For the E3S-C, the optical axis and the mechanical axis are the same, so the optical axis can be easily adjusted by aligning the mechanical axis.



Optical axis: The axis from the center of the lens to the center of the beam for the Emitter and the axis from the center of the lens to the center of the reception area for the Receiver.

Mechanical axis: The axis perpendicular to the center of the lens.



● Operating Environment

Water Resistance

Do not use in water, in rain, or outside.

Ambient Conditions

Do not use this Sensor in the following locations. Otherwise, it may malfunction or fail.

(1) Locations exposed to excessive dust and dirt
(2) Locations exposed to direct sunlight
(3) Locations with corrosive gas vapors
(4) Locations where organic solvents may splash onto the Sensor
(5) Locations subject to vibration or shock
(6) Locations where there is a possibility of direct contact with water, oil, or chemicals
(7) Locations with high humidity and where condensation may result

At low temperatures (0°C or less), the vinyl cable will harden and the wires may break if the cable is bent. Do not bend a Standard or Robot Cable at low temperature.

Environmentally Resistive Sensors

The E32-T11F/T12F/T14F/D12F and D82F can be used in locations (3) and (6) above.

Optical Fiber Photoelectric Sensors in Explosive Gas Atmospheres

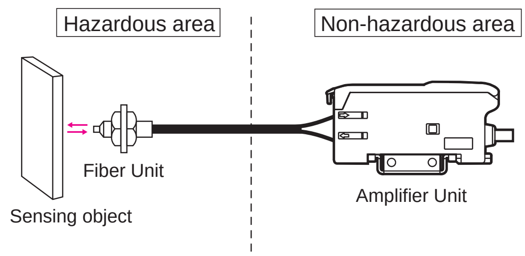
The Fiber Unit can be installed in the hazardous area, and the Amplifier Unit can be installed in a non-hazardous area.

<Reason>

For explosion or fire due to electrical equipment to occur, both the hazardous atmosphere and a source of ignition must be in the same location. Optical energy does not act as an ignition source, thus there is no danger of explosion or fire. The lens, case, and fiber covering are made of plastic, so this setup cannot be used if there is a possibility of contact with solvents that will corrode or degrade (e.g., cloud) the plastic.

<Ignition Source>

Electrical sparks or high-temperature parts that have sufficient energy to cause explosion in a hazardous atmosphere are called ignition sources.



Influence from External Electrical Fields

Do not bring a transceiver near the Photoelectric Sensor or its wiring, because this may cause incorrect operation.

● Maintenance and Inspection

Points to Check When the Sensor Does Not Operate

- If the Sensor does not operate, check the following points.

(1) Are the wiring and connections correct?
(2) Are any of the mounting screws loose?
(3) Are the optical axis and sensitivity adjusted correctly?
(4) Do the sensing object and the workpiece speed satisfy the ratings and specifications?
(5) Are any foreign objects, such as debris or dust, adhering to the Emitter lens or Receiver lens?
(6) Is strong light, such as sunlight (e.g., reflected from a wall), shining on the Receiver?
(7) Do not attempt to disassemble or repair the Sensor under any circumstances.
(8) If you determine that the Sensor clearly has a failure, immediately turn OFF the power supply.

Lens and Case

The lens and case of the Photoelectric Sensor are primarily made of plastic. Dirt should be gently wiped off with a dry cloth. Do not use thinner or other organic solvents.

- The case of the E3ZM, E3ZM-C and E3S-C is metal. The lens, however, is plastic.

● Accessories

Using a Reflector (E39-R3/R37-CA/RS1/RS2/RS3)

During Application

(1) When using adhesive tape on the rear face, apply it after washing away oil and dust with detergent. The Reflector cannot be mounted if there is any oil or dirt remaining.
(2) Do not press on the E39-RS1/RS2/RS3 with metal or a fingernail.This may weaken performance.
(3) This Sensor cannot be used in locations where oil or chemicals may splash on the Sensor.

M8 and M12 Connectors

- Be sure to connect or disconnect the connector after turning OFF the Sensor.
- Hold the connector cover to connect or disconnect the connector.
- Secure the connector cover by hand. Do not use pliers, otherwise the connector may be damaged.
- If the connector is not connected securely, the connector may be disconnected by vibration or the proper degree of protection of the Sensor may not be maintained.

● Others

Values Given in Reference Values

The data and values given as reference values are not ratings and performance and do not indicate specified performance. They are rather values from samples taken from production lots, and are provided for reference as guidelines. Reference values include the minimum sensing object, engineering data, step (height) detection data, and selection list for specifications.

Cleaning

- Keep organic solvents away from the Sensor. Organic solvents will dissolve the surface.
- Use a soft, dry cloth to clean the Sensor.