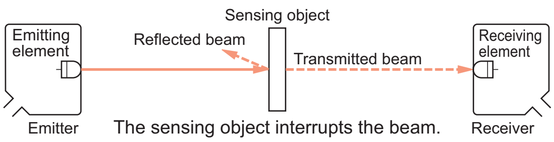
INTRODUCTION

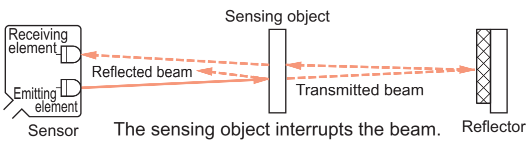
Principles of operation

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

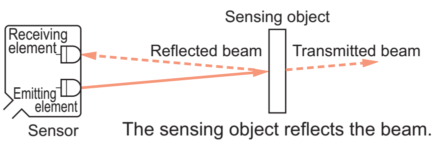
Thru-beam type



Retroreflective type



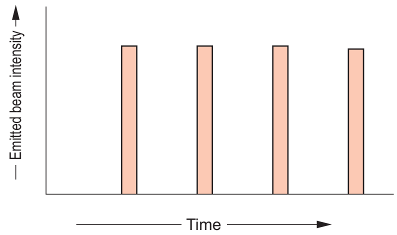
Reflective type



Emitting method

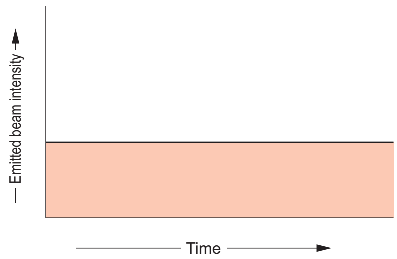
Pulse-modulated

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



Unmodulated

- The high-speed fiber sensor **FX2-A3R** and the micro photoelectric sensor **PM-64/24/44/54** series use an unmodulated beam.
  In this method, the beam is emitted constantly at a fixed intensity. This enables high-speed response, although the sensors are a little susceptible to extraneous light as compared to the sensors using a modulated beam.



FEATURES

Non-contact detection

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

Long sensing range

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

Various objects detectable

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

Short response time

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

Color identification

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

High accuracy detection

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

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

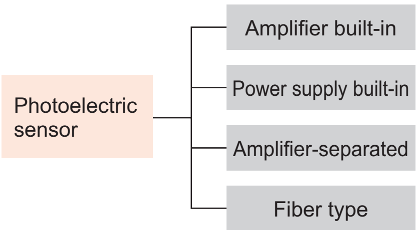
TYPES OF SENSORS

Classification methods

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

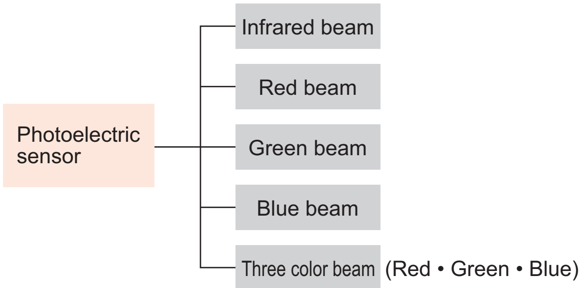
① Classification by structure

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



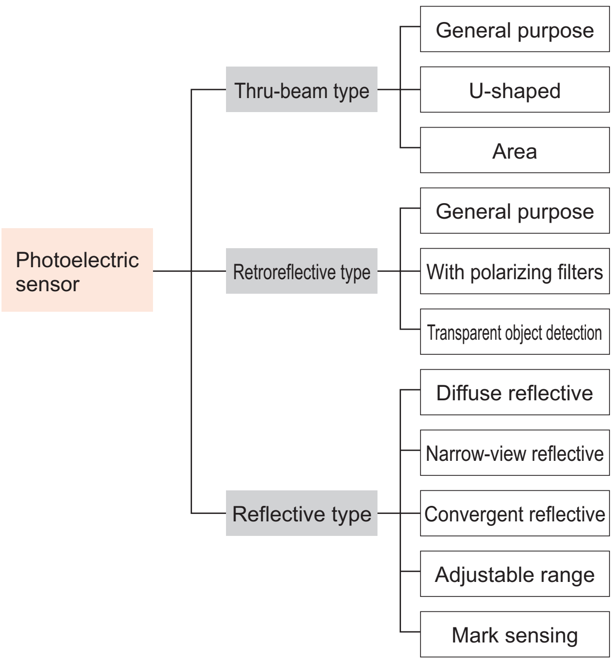
③ Classification by beam source

- This classification is based on the type of beam source used.
This classification is useful to select sensors in view of the sensing distance and the color differences of objects. LED is used on the emitting element. However, we also have the laser sensor uses semi-conductor laser.



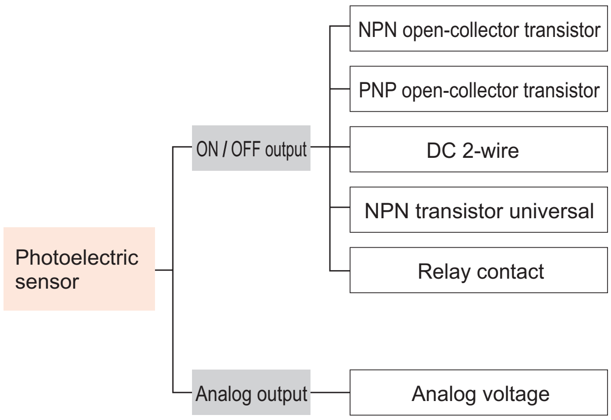
② Classification by sensing mode

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



④ Classification by output circuit

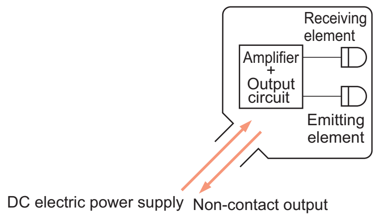
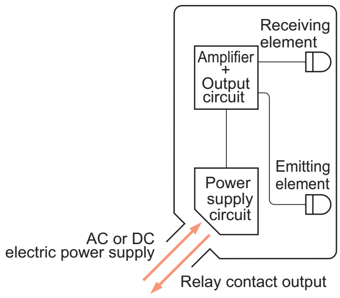
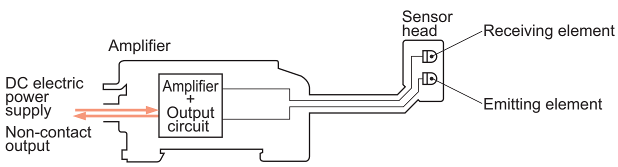
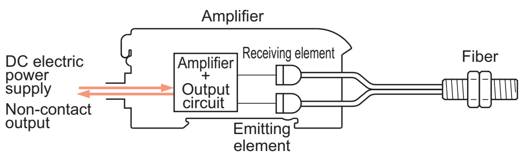
- This classification is based on the type of output circuit and the output voltage.
This classification is useful to select sensors according to the input conditions of the device or equipment connected to the sensor output.



TYPES OF SENSORS

Classification

① Classification by structure

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

Feature comparison table

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

◎: Excellent
○: Good
△: Fair

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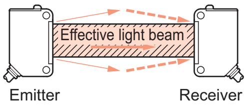
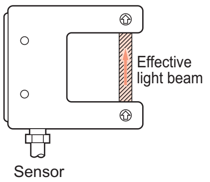
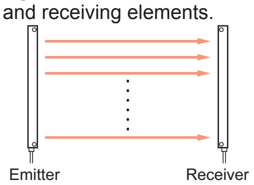
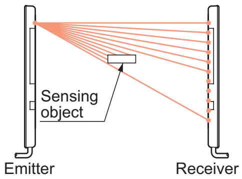
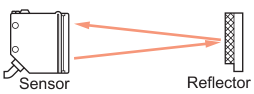
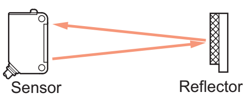
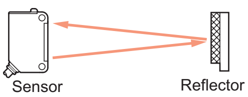
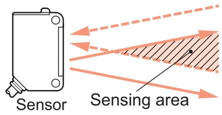
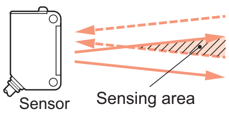
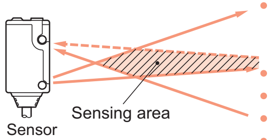
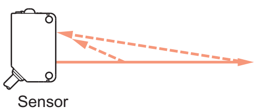
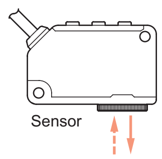
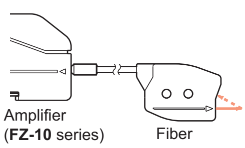
TYPES OF SENSORS

② Classification by sensing mode

Type		Outline and Features
Thru-beam	General purpose	Detects an object that interrupts the light beam traveling from the emitter to the receiver.  • Long sensing range • Precise detection • Small object detectable • Not affected by shape, color or material of sensing objects (opaque) • Resistant to dirt and dust on the lens
Thru-beam	U-shaped	The emitter and the receiver are in one enclosure.  • No beam alignment needed • Precise detection • Small object detectable • Not affected by shape, color or material of sensing objects (opaque) • Resistant to dirt and dust on the lens
Thru-beam	Area	Light curtain or area sensor is made up of arrayed emitting and receiving elements.  * Cross-beam scanning  • Object is detectable as long as it is anywhere in the defined sensing area • Not affected by shape, color or material of sensing objects (opaque) • Resistant to dirt and dust on the lenses • Thin objects, such as post-cards, can be detected (Cross-beam scanning type only. Refer to p.1463)
Retroreflective	General purpose	Detects an object that has a reflectivity smaller than the reflector and interrupts the light beam traveling between the sensor and the reflector.  • Easy beam alignment • Wiring only on one side • Space saving compared to thru-beam type sensors • Not affected by shape, color or material of sensing objects (opaque)
Retroreflective	With polarizing filters	It enables detection of even a specular object by attachment of polarizing filters to the emitting and the receiving parts.(Refer to p.1462)  • Specular object detection • Easy beam alignment • Wiring only on one side • Space saving compared to thru-beam type sensors • Not affected by shape, color or material of sensing objects (opaque)
Retroreflective	Transparent object detection	The specially devised optical system enables detection of even a transparent object.  • Transparent object detection • Easy beam alignment • Wiring only on one side • Space saving compared to thru-beam type sensors • Not affected by shape, color or material of sensing objects

Type		Outline and Features
Reflective	Diffuse reflective	Emits a beam onto the object and detects the object by receiving the beam reflected from the object surface.  • No beam alignment needed • Space saving • Wiring only on one side • Object with fluctuating position detectable • Wide sensing area
Reflective	Narrow-view reflective	The sensing area is narrowed by the optical system.  • Hardly affected by surroundings • More accurate detection compared to diffuse reflective type sensors • No beam alignment needed • Space saving • Wiring only on one side
Reflective	Convergent reflective	Detects an object in the area where the emitting and the receiving envelopes overlap. A spot-beam type sensor detects an object at just the point where these envelopes cross over.  • Less affected by background and surroundings • Precise detection • No beam alignment needed • Space saving • Wiring only on one side
Reflective	Adjustable range reflective	Emits a spot beam onto an object and senses the difference in the reflected beam angle. (Refer to p.1462)  • Virtually not affected by shape, color or material of sensing objects. • Hardly affected by background and surroundings • Small object detectable with high accuracy • No beam alignment needed • Space saving • Wiring only on one side
Reflective	Mark sensing	Projects a spot-beam on the target color, and identifies the color by sensing the amount of reflected beam and the relative ratio among color components. [**FZ-10** series and **LX-100** series (when the color mode is set)] Or projects a spot-beam on an object, and identifies the color by the proportion of the amount of light received (contrast), not by the difference in the amount of the reflected beam. [**LX-100** series (when the mark mode is set)]  (**LX-100** series)  (**FZ-10** series) • Color identifiable • Hardly affected by background and surroundings • Small object detectable with high accuracy • No beam alignment needed • Space saving (**FZ-10** series) • Wiring only on one side

TYPES OF SENSORS

③ Classification by beam source

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

Color combinations that can be discerned during mark sensing

Back-ground color \ Mark color	White	Yellow	Orange	Red	Green	Blue	Black
White		Ⓑ	Ⓑ	ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Yellow	Ⓑ		Ⓖ	Ⓖ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Orange	Ⓑ	Ⓖ		ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Red	ⒼⒷ	Ⓖ	ⒼⒷ		Ⓡ	ⓇⒷ	ⓇⒷ
Green	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	Ⓡ		Ⓑ	Ⓑ
Blue	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ		Ⓑ
Black	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ	Ⓑ	

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

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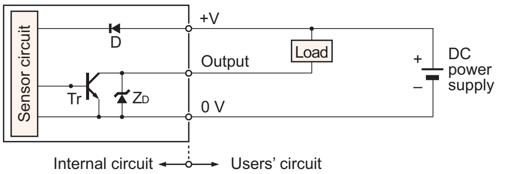
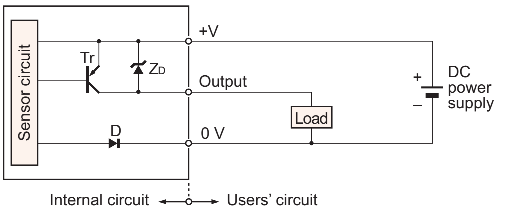
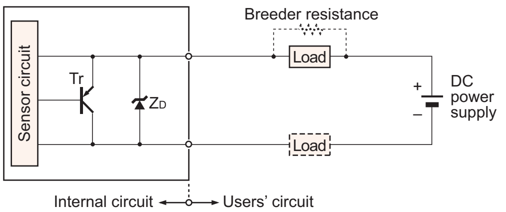
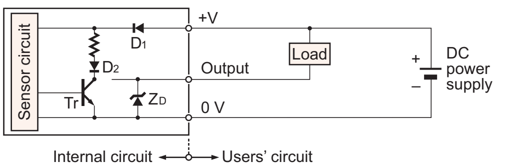
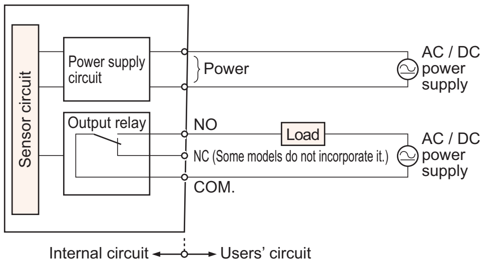
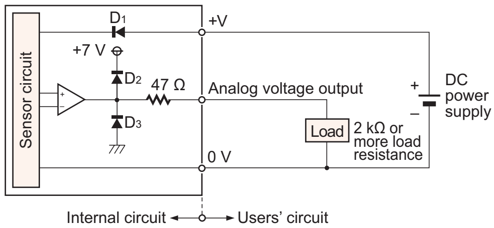
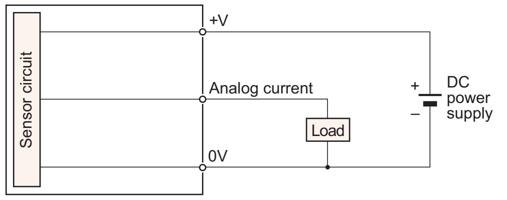
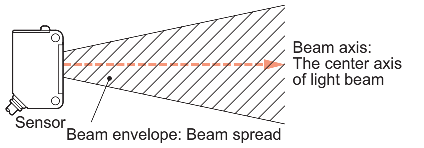
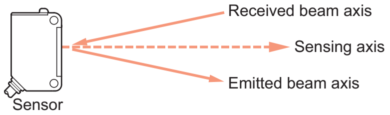
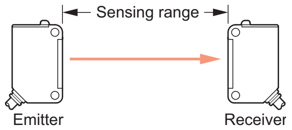
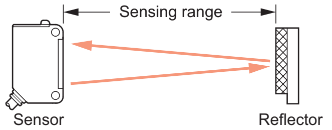
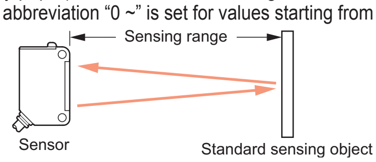
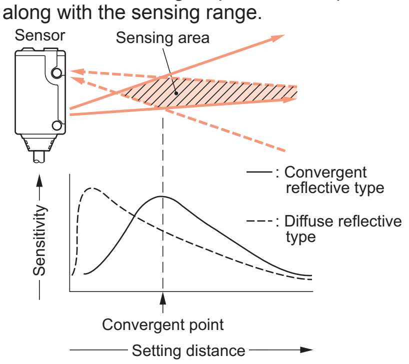
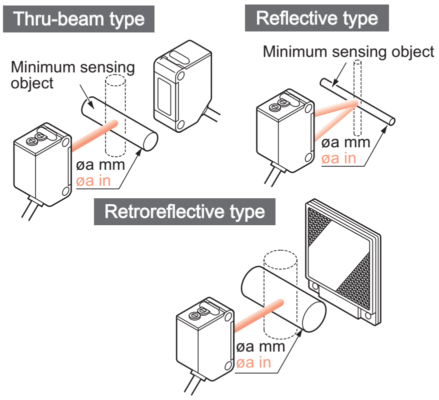
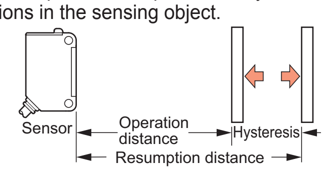
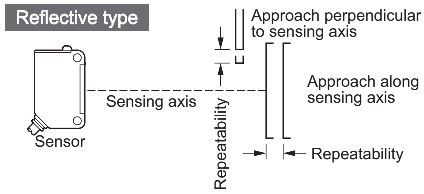
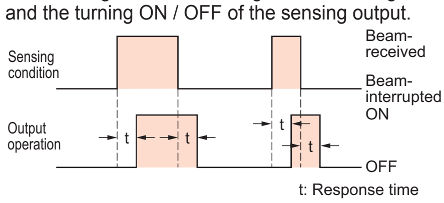
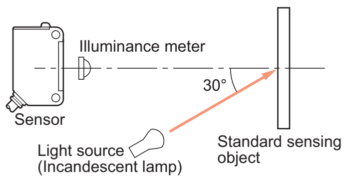
④ Classification by output circuit

Type		Outline and Features
ON / OFF output	NPN open-collector transistor	• Able to drive a relay, PLC, TTL, logic circuit, etc. • A separate power supply can be used for the load. • Long life • High-speed response • Commonly used in North America or Japan  Symbols ... D : Reverse supply polarity protection diode ZD: Surge absorption zener diode (Its position differs with the model.) Tr : NPN output transistor
	PNP open-collector transistor	• Commonly used output circuit in Europe • Power supply is not required for the load. • Long life • High-speed response  Symbols ... D : Reverse supply polarity protection diode (Its position differs with model.) ZD: Surge absorption zener diode (Its position differs with the model.) Tr : PNP output transistor
	DC 2-wire	• Wire saving • Low current consumption • Long life • High-speed response • Limitation on connectable load  Symbols ... ZD: Surge absorption zener diode Tr : PNP output transistor
	NPN transistor universal	• Able to drive a relay, PLC and logic circuit • Long life • A separate power supply can be used for the load. (However, its voltage must be higher than the sensor power supply.) • High-speed response  Symbols ... D1: Reverse supply polarity protection diode (Its position differs with the model.) D2: Reverse current prevention diode (Its position differs with the model.) ZD: Surge absorption zener diode Tr : NPN output transistor

Type		Outline and Features
ON / OFF output	Relay contact	• Drives AC load or DC load • Large switching capacity (A few ampere) • Delayed response compared to non-contact output 
Analog output	Analog voltage	• Outputs an analog voltage proportional to the amount of incident beam  Symbols ... D1: Reverse supply polarity protection diode D2, D3: Surge absorption diode
	Analog current (Monitor current)	• Outputs an analog current (Monitor current) proportional to the amount of incident beam 

GLOSSARY

Term	Description
Beam envelope Beam axis	
Sensing axis	The center axis between the emitted beam axis and the received beam axis. For the thru-beam type sensor, it is identical to the beam axis. 
Sensing range Distance to convergent point	**Thru-beam type** The distance which can be set between the emitter and the receiver under the stable sensing condition. (The abbreviation "0 ~" is set for values starting from 0.)  **Retroreflective type** The distance which can be set between the sensor and the reflector under the stable sensing condition. (The abbreviation "0 ~" is set for values starting from 0.)  **Reflective type** The distance which can be set between the sensor and the standard sensing object (normally, white non-glossy paper) under the stable sensing condition. (The abbreviation "0 ~" is set for values starting from 0.)  * Distance to convergent point: With the convergent reflective type sensor or the mark sensor, sensitivity is not proportional to the setting distance and the maximum sensitivity point is at an intermediate position. This point at which the sensitivity is maximum is called the convergent point and is specified along with the sensing range. 
Standard sensing object	The standard sensing object for determining the basic specifications of reflective type sensors. Normally, it is white non-glossy paper, but some particular sensors use other objects to suit the application. (e.g., glass)

Term	Description
Minimum sensing object	The minimum object size that the sensor can detect under the specified conditions. In the thru-beam type and the retroreflective type, the size of an opaque object (completely beam interrupted object) is specified. In the diffuse reflective type, the diameter of a gold wire or a copper wire is specified. (øxxx mm øxxx in value is expressed) 
Hysteresis	For a reflective sensor, the hysteresis is the difference between the operation distance, when the output first results in light-ON with the standard sensing object approaching along the sensing axis, and the resumption distance, when the output first results in light-OFF with the standard sensing object receding. It is displayed as a percentage (%) versus the operation distance. The movement distance is displayed as a percentage (%). Hysteresis prevents output instability caused by vibrations in the sensing object. 
Repeatability	The difference in the operating position when operation is repeated under constant conditions. 
Response time	The time lag between a change in the sensing state and the turning ON / OFF of the sensing output. 
Ambient illuminance	The maximum ambient light intensity that does not cause sensor malfunction. It is expressed as the permissible light intensity at the light receiving face. The illuminance is stipulated to be an incandescent lamp. * Sunlight has two or three times the illuminance of an incandescent lamp. Before use, refer to "Influence of extraneous light" (p.1459) described in "PRECAUTIONS FOR PROPER USE". 

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GLOSSARY

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

Protection

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

IEC standard

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

• Protection degree specified by the first figure

First figure	Description
0	No protection
1	Protection against contact with internal live parts by a human hand (ø50 mm ø1.969 in)
2	Protection against contact with internal live parts by a human finger (ø12 mm ø0.472 in)
3	Protection against contact with internal live parts by a solid object more than 2.5 mm 0.098 in in thickness or diameter
4	Protection against contact with internal live parts by a solid object more than 1.0 mm 0.039 in in thickness or diameter
5	Protection against dust penetration which can affect operation
6	Complete protection against dust penetration

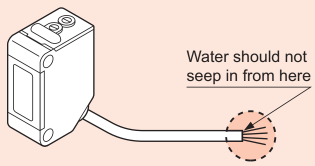
Note: The IEC standard prescribes test procedures for each protection degree given above. The protection degree specified in the product specifications has been decided according to these tests.

• Protection degree specified by the second figure

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

Caution

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



IP67G / IP68G

This specifies protection against oil in addition to IP67 / IP68 protection of IEC standards. It specifies that oil drops or bubbles should not enter from any direction.

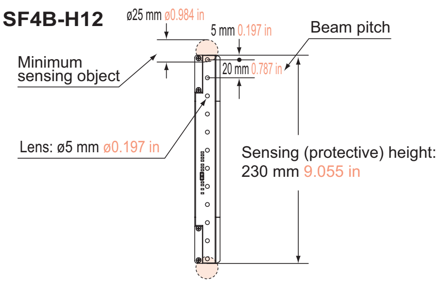
Sensing height (Protective height)

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

Example: in the case of a 20 mm 0.787 in beam pitch

<**SF4B**(**-01**) (Note) / **SF2B** series / **SF4C** series>
• Sensing height (protective height) is the same length as the light curtain body.

(e.g.) **SF4B-H12**



Notes: **SF4B-01** series are used for purposes other than for press in Japan.

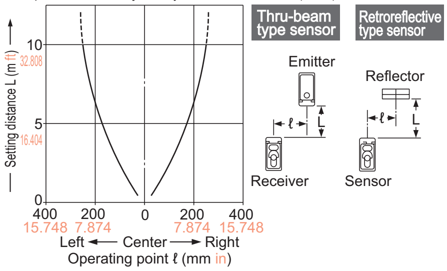
* Refer to "**Definition of light curtains and area sensor sensing heights** (p.727)" for sensing height of other light curtains and area sensors.

GLOSSARY

Term	Description

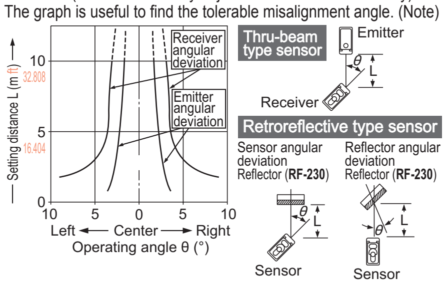
Parallel deviation

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



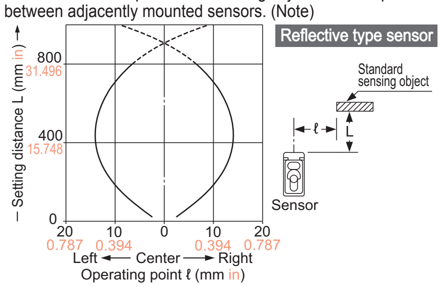
Angular deviation

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



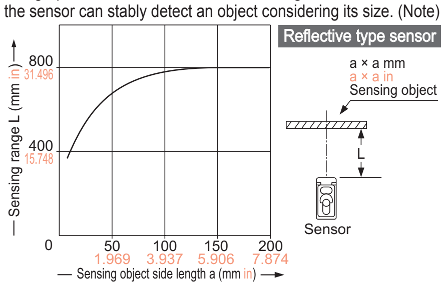
Sensing field

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



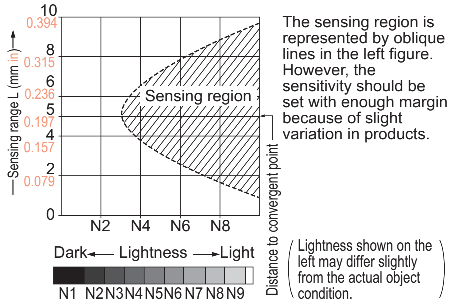
Correlation between sensing object size and sensing range

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



Correlation between lightness and sensing range

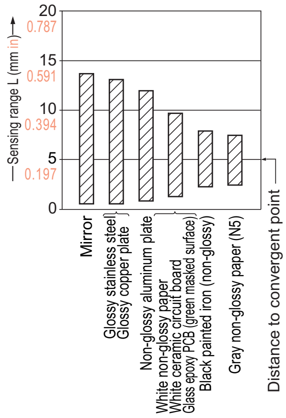
This diagram of the convergent reflective type sensor gives the correlation between lightness and sensing range.
The graph is useful to determine the sensing distance for which the sensor can reliably detect an object considering its lightness. (Note)



The sensing region is represented by oblique lines in the left figure. However, the sensitivity should be set with enough margin because of slight variation in products.

Correlation between material and sensing range

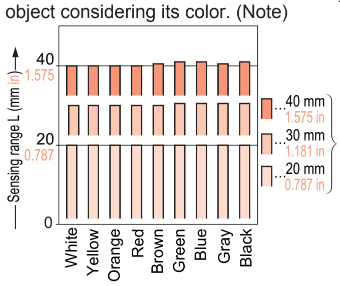
This diagram of the convergent or the adjustable range reflective type sensor gives the correlation between object material and sensing range.
The graph is useful to determine the sensing distance for which the sensor can reliably detect an object considering its material. (Note)



The bars in the graph indicate the sensing range for the respective material. However, there is a slight variation in the sensing range depending on the product. Further, if there is a reflective object (conveyor, etc.) in the background of the sensing object, since it affects the sensing, separate it by more than twice the sensing range shown in the left graph.

Correlation between color and sensing range

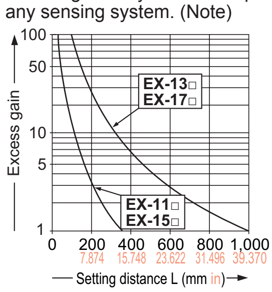
This diagram of the adjustable range reflective type sensor gives the correlation between color and sensing range.
The graph is useful to determine the sensing distance for which the sensor can reliably detect an object considering its color. (Note)



These bars indicate the sensing range with the respective colors when the distance adjuster is set at the sensing range of 40 mm 1.575 in, 30 mm 1.181 in and 20 mm 0.787 in long, each, with white color.

Correlation between setting distance and excess gain

Excess gain is a measurement of the sensing energy falling on the receiver element of a sensing system over and above the minimum amount required to operate the sensor.
Excess gain may be used to predict the reliability of any sensing system. (Note)



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

PRECAUTIONS FOR PROPER USE

Setting distance

Thru-beam type and retroreflective type sensors

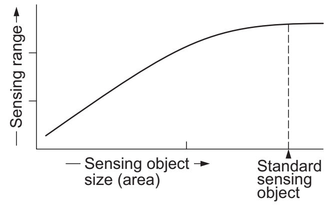
- The setting distance must be equal to or less than the specified sensing range.
  The sensors may be operable at a setting distance longer than the rated sensing range, but reliable operation cannot be guaranteed. Further, in a dirty or dusty environment, the setting should provide margin for beam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

Reflective type sensors

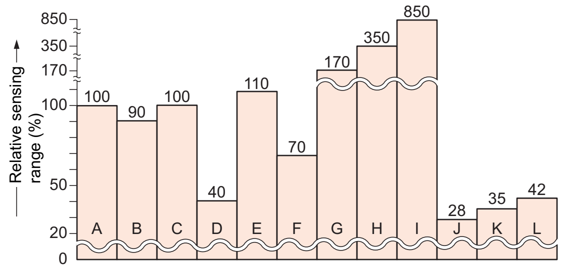
- The sensing range given in the specifications is for the standard sensing object.
  Since the actual sensing distance differs with the size, color, surface condition, etc., of the sensing object, set the sensor giving enough margin for these differences.

<Change of sensing range with sensing object size>

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



<Change of sensing range with sensing object>
(Diffuse reflective type sensors)



A: White non-glossy paper (Standard)
B: Natural color card-board
C: Plywood
D: Black non-glossy paper (Lightness: 3)
E: Plywood (glossy)
Bakelite board (Natural color)
Acrylic board (Black)
Vinyl leather (Red)
F : Vinyl leather (Gray)
G: Rubber sheet (Green glossy)
H: Aluminum sheet
I : Reflex reflector
J : ø10 mm ø0.394 in rusted steel rod
ø5 mm ø0.197 in brass pipe
K: Cloth (Black)
L : Cloth (Dark blue)

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

Mounting

Mutual interference

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

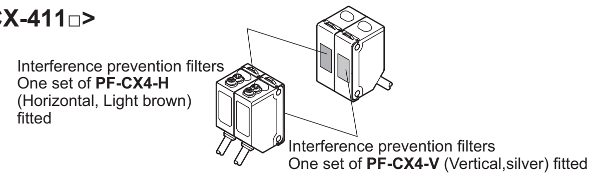
Countermeasure ①: Use sensors having interference prevention function.

When sensors having the interference prevention function are used, sensors can be mounted close together.

Countermeasure ②: Use interference prevention filters.

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

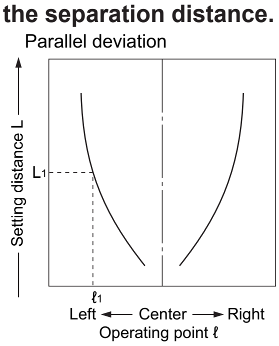
<CX-411□>

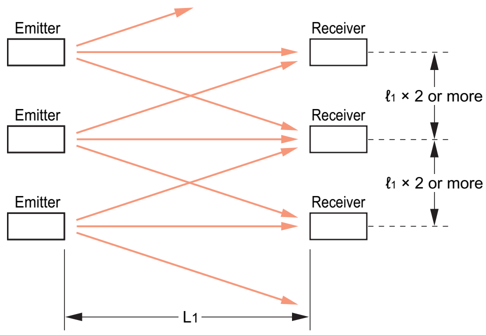


Countermeasure ③: Increase the separation distance.

Find out the operating point ℓ1 on the parallel deviation diagram or the sensing field diagram for the setting distance L1. Separate sensors by 2 × ℓ1 or more.

(However, it is required that the emitter and receiver face each other and are installed in a direct line.)





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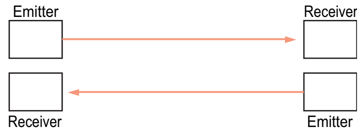
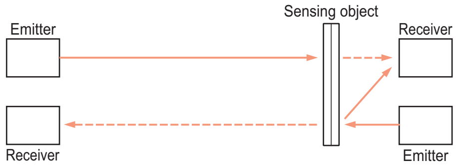
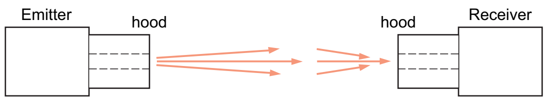
Countermeasure ④: Place the emitter and the receiver alternately. (Thru-beam type sensors only)



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



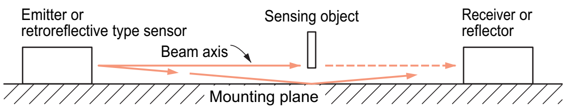
Countermeasure ⑤: Narrow the light beam with a hood or a slit mask. (Thru-beam type sensors only)



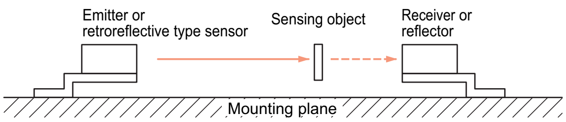
Influence of surroundings

<Thru-beam type and retroreflective type sensors>

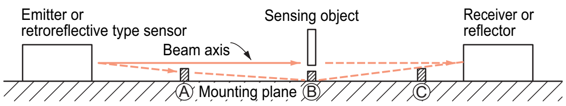
- If a thru-beam type sensor, or a retroreflective type sensor is mounted on a flat shiny plane, the emitted beam may not be interrupted by a sensing object because some amount of the emitted beam passes through the gap between the sensing object and the plane, gets reflected from the plane, and enters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



Countermeasure ①: Increase distance from the mounting plane.



Countermeasure ②: Place light barriers on the mounting plane.



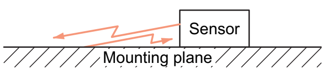
Place light barriers at Ⓐ, Ⓑ and Ⓒ to prevent reflection.

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

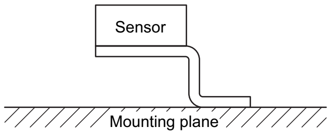
<Reflective type sensors>

Effect of mounting plane

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



Countermeasure ①: Increase distance from the mounting plane.



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

Influence of background

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

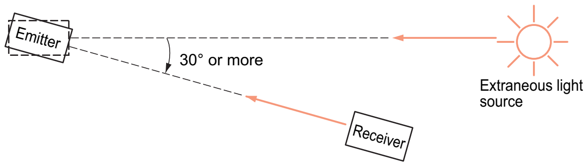
Countermeasures:

- Remove the background.
- Paint the background in black color.
- Increase the distance from the background.
- Use a adjustable range reflective sensor or a convergent reflective sensor.
  (However, the specular background should be a plane surface, directly facing the sensor. A spherical or curved background may be detected.)

Influence of extraneous light

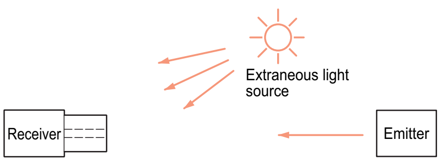
- Most of the sensors use modulated beam highly immune to sunlight or ordinary fluorescent light. However, intense light or light from inverter fluorescent lamps may affect the sensor operation.

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



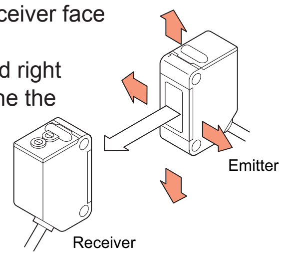
The incident angle and wavelength of the sunlight vary depending on the seasons, time of day, or other reasons. Thus, the influence that the sunlight has on sensors changes. For this reason, make sure to confirm that a malfunction does not occur with actual sensors before use.

Countermeasure ②: Attach a hood on the receiver.



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

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



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

Caution: The directional characteristics of photoelectric sensors can vary, so please be sure that you can adjust the beam axis using mounting brackets, etc. upon use.

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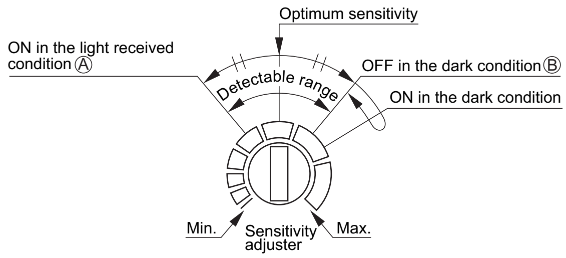
Sensitivity adjustment

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

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

Note: Refer to the “PRECAUTIONS FOR PRPOER USE” page of each product for adjustable range reflective type sensors.



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

For models equipped with auto sensitivity setting function, sensitivity adjustment is performed with a single touch of a button without the sensitivity adjustment described above.

Color discrimination during mark sensing

Color mark sensing

- Marks can be sensed with mark sensor **LX-100** series or color fiber sensor **FZ-10** series, mark sensor or fiber sensor.

LX-100 series

<When the mark mode is set>

- The optimal light source is automatically selected from the 3 colors of the R · G · B LEDs so that the contrast between the mark and base becomes the largest. This makes detection more stable.

<When the color mode is set>

- The color mode utilizes all the R · G · B LEDs and detects the reflected light by calculating the R · G · B ratio. Thus, high precision detection is possible by sensing only the mark color that teaching was performed on.

FZ-10 series

- The **FZ-10** series uses red, green and blue LEDs to identify a color by its three color components. Hence, it is able to discriminate even minute color differences.

Mark sensors, Fiber sensors

- For mark sensors and fiber sensors, the color combinations of the mark and the background which can be discriminated, depending on the color of the light source, are as given in the table below.

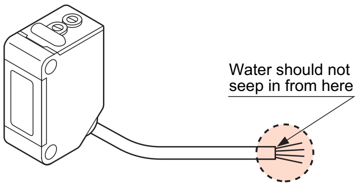
Background color \ Mark color	White	Yellow	Orange	Red	Green	Blue	Black
White		Ⓑ	Ⓑ	ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Yellow	Ⓑ		Ⓖ	Ⓖ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Orange	Ⓑ	Ⓖ		ⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ
Red	ⒼⒷ	Ⓖ	ⒼⒷ		Ⓡ	ⓇⒷ	ⓇⒷ
Green	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	Ⓡ		Ⓑ	Ⓑ
Blue	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ		Ⓑ
Black	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒼⒷ	ⓇⒷ	Ⓑ	Ⓑ	

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

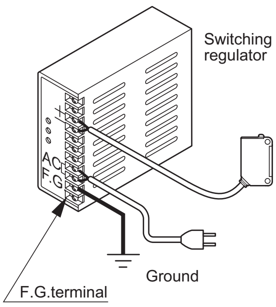
PRECAUTIONS FOR PROPER USE

Other precautions

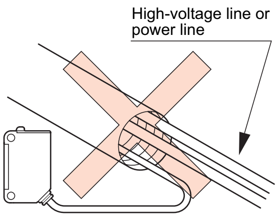
- Our products have been developed / produced for industrial use only.
- Although the protection degree is specified for the sensor including the cable, the cable end is not waterproof and is not covered by the protection specified. Hence, make sure that water does not seep in from the cable end.



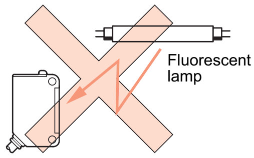
- Make sure that the power supply is off while wiring.
- Verify that the supply voltage variation is within the rating.
- If power is supplied from a commercial switching regulator, ensure that the frame ground (F.G.) terminal of the power supply is connected to an actual ground.



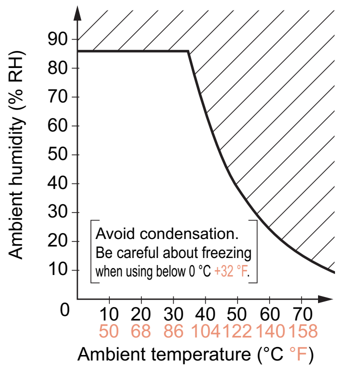
- In case noise generating equipment (switching regulator, inverter motor, etc.) is used in the vicinity of this product, connect the frame ground (F.G.) terminal of the equipment to an actual ground.
- Do not run the wires together with high-voltage lines or power lines or put them in the same raceway.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



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



- These sensors are only for indoor use.
- Make sure that stress by forcible bend or pulling is not applied directly to the sensor cable joint.
- The usage environment should be within the ranges described in the specifications. In addition, the thru-beam type specifications for the emitter and receiver were measured under the same environment.
  Use sensors within the range shown in the white part of the ambient temperature / humidity graph below and also within the certified ambient temperature and humidity range of each product. When using sensors within the range shown in the diagonal line shaded part of the graph, there is a possibility that condensation may occur depending on changes in the ambient temperature. Please be careful not to let this happen.
  Furthermore, pay attention that freezing does not occur when using below 0 °C +32 °F. Please avoid condensation and freezing when storing the product as well.

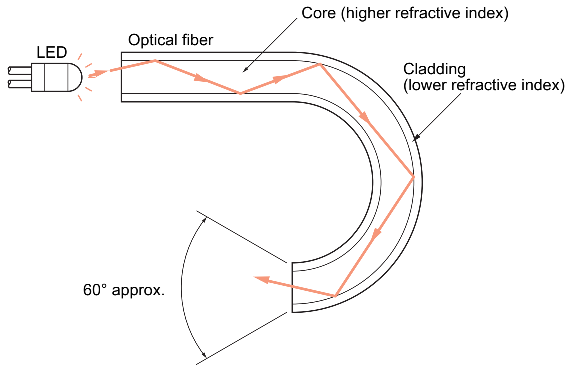


PRINCIPLES OF PARTICULAR OPTICAL SENSING SYSTEMS

Fiber cables

Principle of optical fiber

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

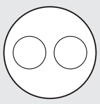
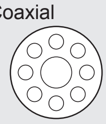
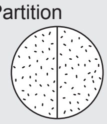


Types of fiber cables and their features

Type	Features
Plastic	The fiber is made of acrylic. The core is made up of one or several ø0.125 to ø1.5 mm ø0.005 to ø0.059 in acrylic resin fibers. It is widely used because of its low price. The sharp bending fiber is made up of several hundred ø0.075 mm ø0.003 in acrylic resin fibers bound together into a single multi-core fiber, so that it can be bend at right angles without causing a decrease in light intensity or breaking.
Glass	The fiber is made of glass that provides better heat-resistance and chemical-resistance than plastic. The cable consists of multiple fiber strands of ø0.05 mm ø0.002 in. It is used mainly for special applications because of its high price.

Fiber cable structure

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

Cable structure	Description
Parallel 	Generally used for plastic fiber cables.
Coaxial 	The center fiber is for beam emission, and the surrounding fibers are for receiving the beam. This structure is suitable for high accuracy measurements since the sensing position does not change with the travel direction of the sensing object.
Partition 	Generally used for glass fiber cable. It comprises of a number of glass fiber strands of ø0.05 mm ø0.002 in, and is divided into the emitting part and the receiving part.

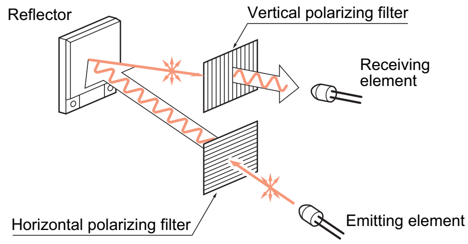
Retroreflective type sensor with polarizing filters

Principle

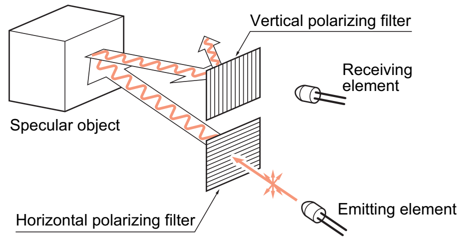
- Opposite types of polarizing filters are placed in front of the emitting and receiving elements. A horizontal polarizing filter placed in front of the emitting element passes only horizontally polarized light and a vertical polarizing filter placed in front of the receiver ensures that only vertically polarized light is received. Using this configuration, even specular objects can be reliably detected.

① Normal unpolarized beam emitted from the LED oscillates in a random manner. As it passes through the horizontal polarizing filter, the oscillation is aligned horizontally and the beam is horizontally polarized.

② When the polarized beam falls on the reflector, its polarization is destroyed and the reflected beam oscillates in a random manner. So, the reflected beam can pass through the vertical polarizing filter and reach the receiving element.

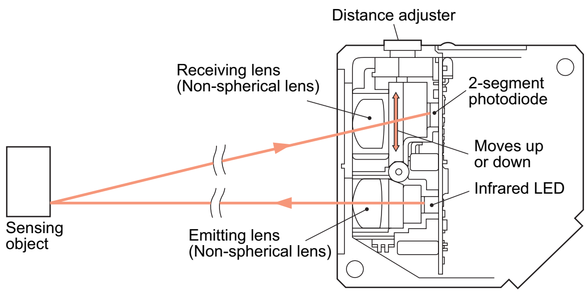


However, a specular object does not destroy the polarization. The reflected beam oscillates horizontally, as before, and cannot pass through the vertical polarizing filter.



Adjustable range reflective type photoelectric sensor

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



- We also have the **MQ-W** series that uses two PSDs (Position Sensitive Detector) on the receiving element for one emitting element in order to improve reliability.

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PRINCIPLES OF PARTICULAR OPTICAL SENSING SYSTEMS

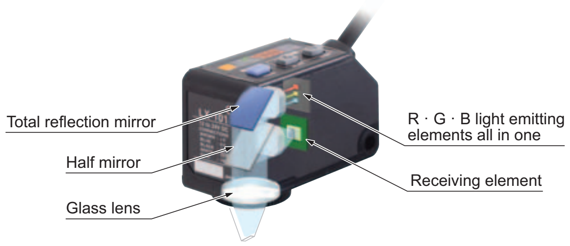
Digital mark sensor / LX-100 series

When the mark mode is set

- The optimal light source is automatically selected from the 3 colors of the R · G · B LEDs so that the contrast between the mark and base becomes the largest. This makes detection more stable.

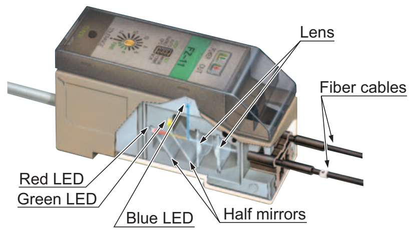
When the color mode is set

- The color mode utilizes all the R · G · B LEDs and detects the reflected light by calculating the R · G · B ratio. Thus, high precision detection is possible by sensing only the mark color that teaching was performed on.



Color detection fiber sensor / FZ-10 series

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

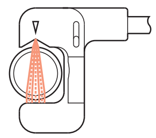


Liquid level detection sensor (Pipe-mountable type)

Thru-beam type

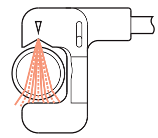
- When liquid is present, the lens focuses as per the liquid lens effect and the beam is received.

<Filled pipe>



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

<Empty pipe>

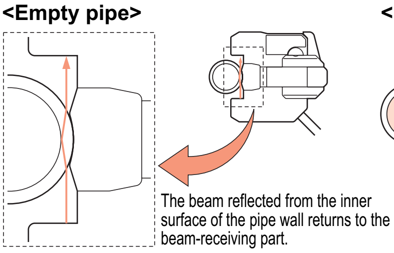


The beam is scattered and not received.

Reflective type

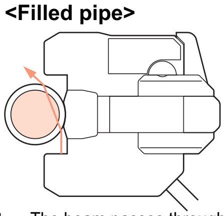
- When the pipe is empty, the beam is reflected from the inner surface of the pipe wall and returns to the beam-receiving part since the difference in the refractive indexes of the pipe and air is large. When there is liquid in the pipe, the beam enters the liquid through the wall and does not return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

<Empty pipe>



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

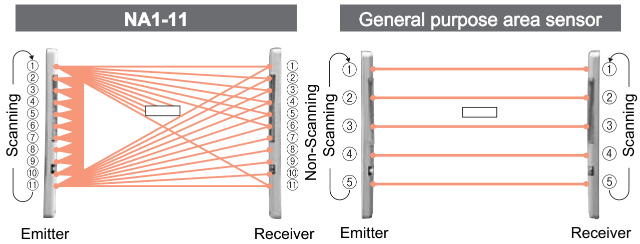
<Filled pipe>



The beam passes through the wall into the liquid.

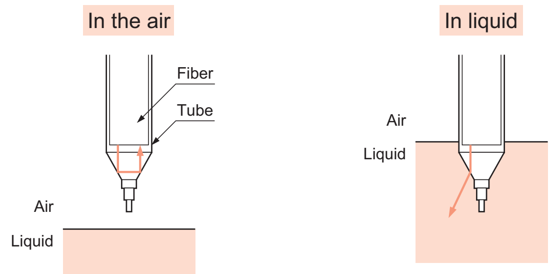
Cross-beam scanning (NA1-11)

- In a conventional area sensor, slim objects cannot be detected since the emitting and the receiving elements are scanned, synchronously, as a set. In contrast, in **NA1-11**, only the elements ① to ⑪ of the emitter are scanned to obtain emission. The elements of the receiver are not scanned, so that when element ① of the emitter emits light, all the elements of the receiver receive light. Hence, even if there is one element on the receiver which does not receive light, it results in light interrupted operation. With this technique, detection of slim objects is possible.



Liquid level detection fiber (Contact type)

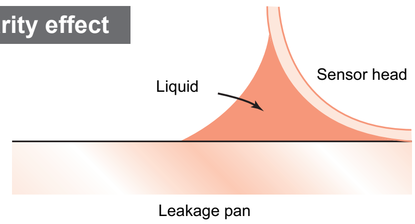
- When the fiber tip is in the air, as there is a large difference between the air and the tube refractive indexes, the tube boundary reflects the emitted beam back to the receiver. On the other hand, when the fiber tip is immersed in a liquid, the emitted beam scatters from the fiber into the liquid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



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

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

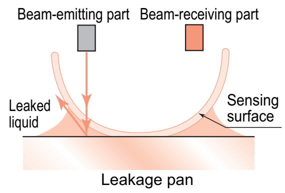
Capillarity effect



New type of detection method

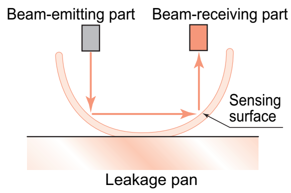
- When a leak occurs, the beam from the beam-emitting part scatters through the leaked liquid and is not transmitted to the beam-receiving part.

<When leakage occurs>



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

<When there is no leakage>



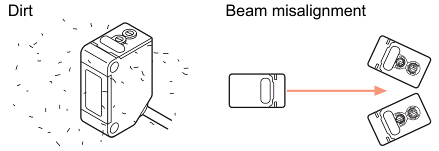
The beam from the beam-emitting part reflects off of the surface of the sensor and is transmitted to the beam-receiving part.

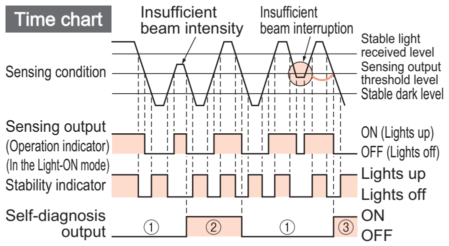
FUNCTIONS

Function	Description

Self-diagnosis function

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





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

- Since the time chart differs with the sensor model, please refer to the section “PRECAUTIONS FOR PROPER USE” of the respective sensor series.
- The **SF4B-C** series,**SF4B** series, **SF4C** series, **BSF4-AH80**, **SF2B** series, **SF2C** series etc., have a self-diagnosis function for the internal circuitry besides the above mentioned self-diagnosis function for the light incident intensity.

Light intensity monitor

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

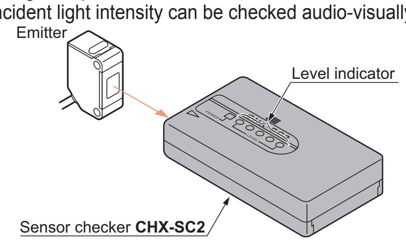
FX-500 / FX-100 / FX-300 / FX-410 series, FX-301-F, LS series, LX-100 series

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

- (e.g.)**FX-500** series

Infrared or red beam type of thru-beam photoelectric sensors

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

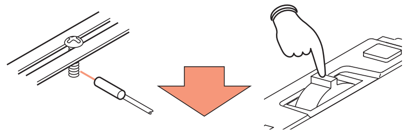


Function	Description

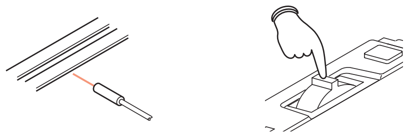
Automatic sensitivity (threshold value) setting

Sensitivity (threshold value) setting is done simply by pressing a button.

Press the jog switch (Note) with the object in front of the fiber.



Press the jog switch (Note) without the object.



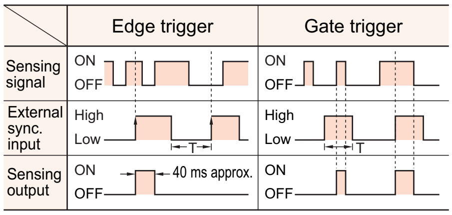
Note: The **FX-300** series and **LS** series are equipped with a jog switch.
The **FX-500** series, **FX-100** series, and **LX-100** series use button operations.

The **FX-500** series, **FX-100** series, **FX-300** series, **LS** series and **LX-100** series feature a full auto-teaching function by which sensitivity setting can be done on a moving object without stopping the assembly line. Further, in case of the **FZ-10** series and **SU-7** series, sensitivity setting is done by using a button switch.

External synchronization function

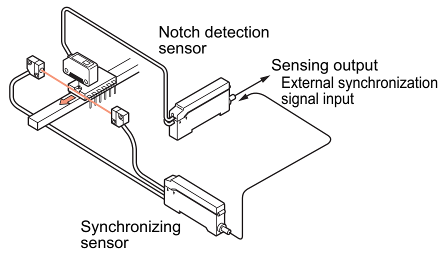
The timing of sensing can be controlled.

- Time chart (with **SU-75**)



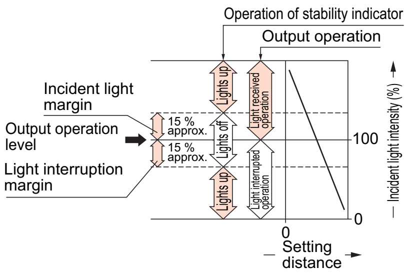
T ≥ 0.6 ms (when the interference prevention function is used, T ≥ 0.8 ms)

- Application
Checking orientation of IC

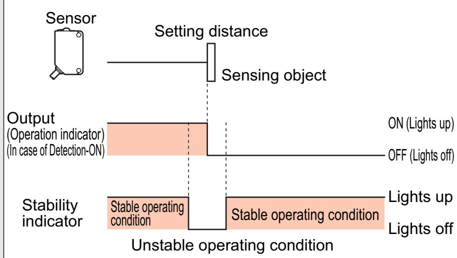


FUNCTIONS

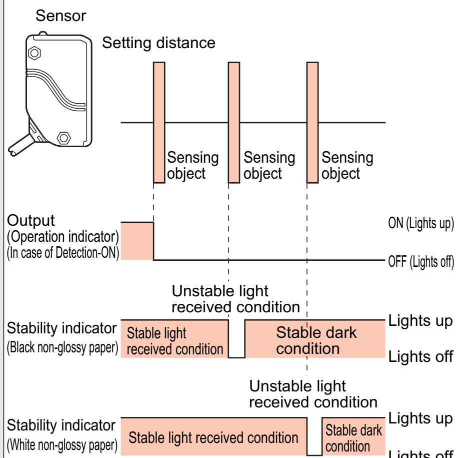
Function	Description
Stability indicator	The stability indicator (green) lights up when the incident light intensity has sufficient margin with respect to the operation level. If the incident light intensity level is such that the stability indicator lights up, stable sensing can be done without the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



- In case of the **NA2-N** series, **NA1-PK5** series, **NA1-5** series and **NA1-PK3** series, this is the stable incident beam indicator and lights up when the incident light margin is exceeded.
- The stability indicator (green) of the **CX-440** series and **EQ-500** series shows the safety margin of the setting distance.



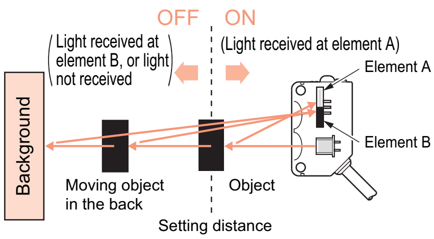
- The stability indicator (green) of the **EQ-30** series shows the safety margin of the incident light intensity, not that of the object distance. Hence, the distance at which it lights up / off depends on the object reflectivity and is not at all related to the output operation. Do not use the sensor when the stability indicator is off (unstable light received condition), since the sensing will be unstable.



Function	Description
BGS / FGS functions	Depending on the positional relation between the background and the sensing object, either the BGS or FGS function will be selected.

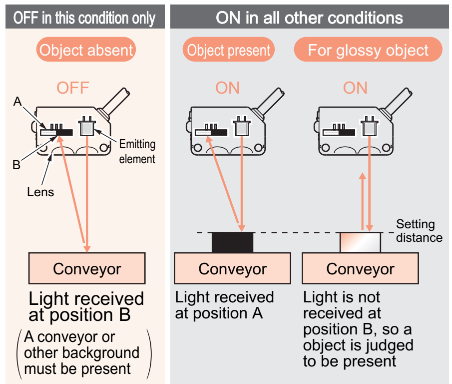
BGS (Background suppression)

The sensor judges that an object is present when light is received at position A of the light-receiving element (2-segment element).
This is useful if the object and background are far apart. The distance adjustment method is the same as the conventional adjustment method for adjustable range reflective type sensors.



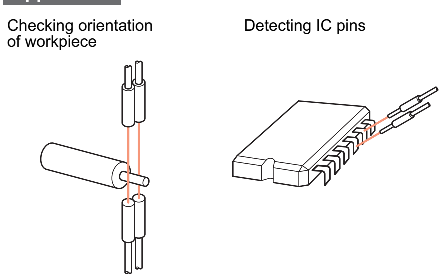
FGS (Foreground suppression)

The sensor judges that an object is present when no light is received at position B of the light-receiving element (2-segment element).
Accordingly, even objects that are glossy can be sensed. This is useful if the object and background are close together, or if the object being sensed is glossy.



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

Application



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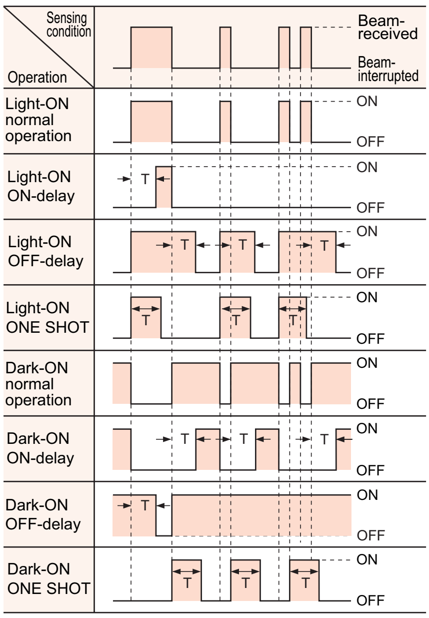
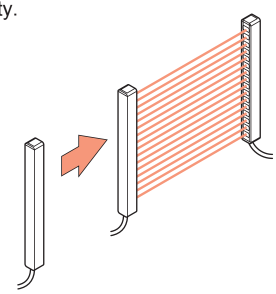
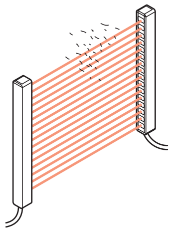
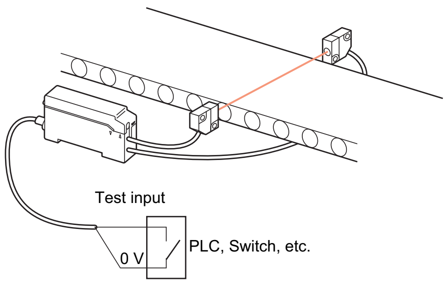
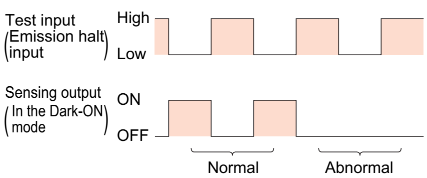
Function	Description
Timer function	The width of the output signal is controlled to match the connected device specifications. **ON-delay** Function: Neglects short output signals. Application: As only longer signals are extracted, this function is useful for detecting if a line is clogged, or for sensing only objects taking a long time to travel. **OFF-delay** Function: Extends the output signal for a fixed period of time. Application: This function is useful if the output signal is so short that the connected device cannot respond. **ONE SHOT** Function: Outputs a fixed width signal upon sensing Application: This function is useful when the input specifications of the connected device require a signal of fixed width. Of course, it is also useful for extending a short width signal to a desired width. • Time chart  T: Timer period The **FX-500** series, **FX-305**(**P**) is equipped with an ON-delay / OFF-delay timer that allows you to use ON and OFF-delay simultaneously as well as an ON-delay / ONE SHOT timer enabling a simultaneous ON-delay and ONE SHOT.

Function	Description
Automatic sensitivity compensation function	The sensitivity is adjusted according to the setting distance to maintain the optimum sensitivity.  The sensitivity is reduced if the emitter and the receiver are brought closer.  The sensitivity is increased in case of dust or dirt.
Test input (emission halt input) function	The emission can be stopped by an external test input. • Application Start-up inspection  • Time chart  When several sensors are arrayed in a line, this function can also be used for mutual interference prevention by controlling the beam emission in a cyclic manner. Note: Set the operation setting to light-ON for **FX-502**(**P**).