Troubleshooting case studies

[Optical Sensor]

Must read! To get the correct performance out of optical sensors

? Cause & ! Remedies

Introduction

This publication provides a summary of the probable causes and solutions of past failures related to optical sensors: photomicrosensors (photointerrupters) and light convergent/diffuse reflective sensors.
Use this information as a reference when designing a new product using optical sensors, or when unexpected problems occur.

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CASE 1

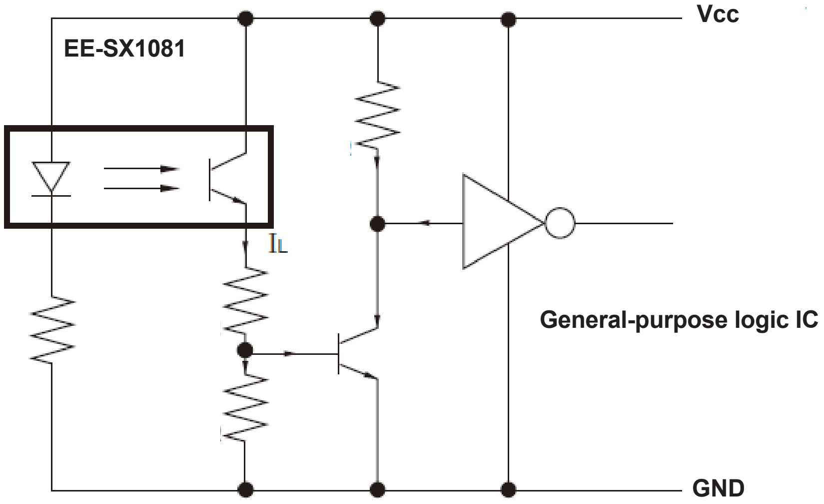
Malfunction due to circuit design factors

Photomicrosensors (photointerrupters) are semiconductor components. Therefore, there are variations among individual products in characteristics such as light emitting power of the emitter (LED) and photosensitivity (light current) of the receiver. In addition, LED-specific characteristics and changes in the operating environment, such as temperature, must also be considered when designing circuits.

■ Malfunction case

- ◆ Some sensors did not have problems during prototyping but do not operate as designed on mass production.
- ◆ Although all the products passed shipping tests, the sensor malfunction occurred in the market several years later.

[Phototransistor output type photomicrosensor: Application circuit example]



* For details on circuit design, please refer to “Photomicrosensor Basics: Design I & II”.

Probable cause of failure

The above-mentioned malfunctions may be caused by not taking into account the following items in circuit design.

(1) Individual product variation: For phototransistor output type, specified range of light current (I_L)

(2) LED aging: Light emitting power decreases with power-on time (= decrease in light current (I_L))

(3) Effects of operating environment: Light current (I_L) variation due to ambient temperature, dust, external disturbing light, etc.

(4) Influence of sensing object: In the case of reflective type, changes in light current (I_L) due to variations in the sensing object (e.g. color, surface condition), changes in the position/angle of the object, discoloration of the object, changes in reflectance due to dirt, etc.

Solution

The following items should be considered in the circuit design of photomicrosensors.
For details, please refer to "Photomicrosensor Basics: Design I & II".

(1) Consider individual product variation (for phototransistor output)

The table below shows the light current (I_L) of a typical slot photomicrosensor: EE-SX1081.

Detector							
	Light current	I_L	0.5	-	14	mA	I_F=20mA, V_{CE}=10V

In the circuit design of a sensor, it is necessary to verify that the sensor with the lower or upper limit of this specified range of light current (I_L) can operate. When detecting an object that does not transmit light (completely light blocking) by a slot sensor, it can be said that only the lower limit value should be considered, unless there are special circumstances.
As for the reflective type, it is sufficient to consider the lower limit for simple detection of presence or absence of a sensing object. For applications such as when there is a background object or when a mark is detected on a paper surface; however, the upper and lower limits of the light current (I_L) must be considered. The table below shows the light current (I_L) of a typical reflective type: EE-SY110.

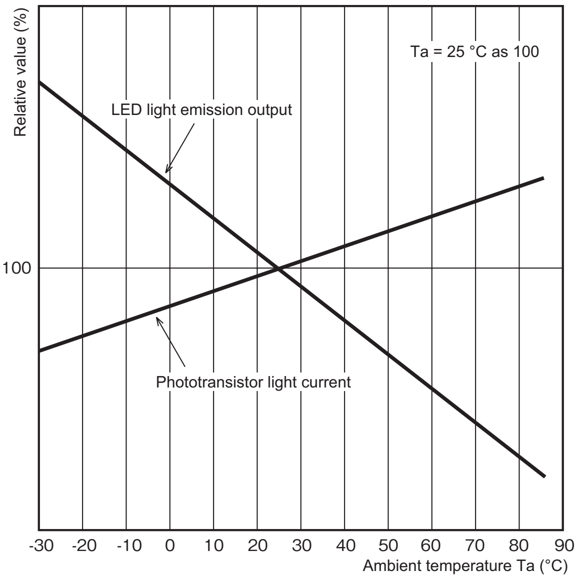
Detector							
	Light current	I_L	200	-	2000	μA	I_F=20mA, V_{CE}=10V Reflectance 90% White paper, d=5mm *

The table shows that the light current (I_L) varies within a range of 200 μA to 2,000 μA, depending on a unit.
The ratio of the upper and lower limits is 200/2,000 = 10 times. Therefore, in actual applications, if I_L (S) is the light current when an object is detected and I_L (N) is the light current when the object is not detected, and if the S/N ratio (I_L (S)/I_L (N)) is under 10 times, the circuit with a fixed threshold value may not turn on or off, depending on the unit. In such a case, either (1) adjust the threshold value for each sensor at the time of product assembly, or (2) use a circuit that can automatically set the threshold value according to the light current value of the mounted sensor.

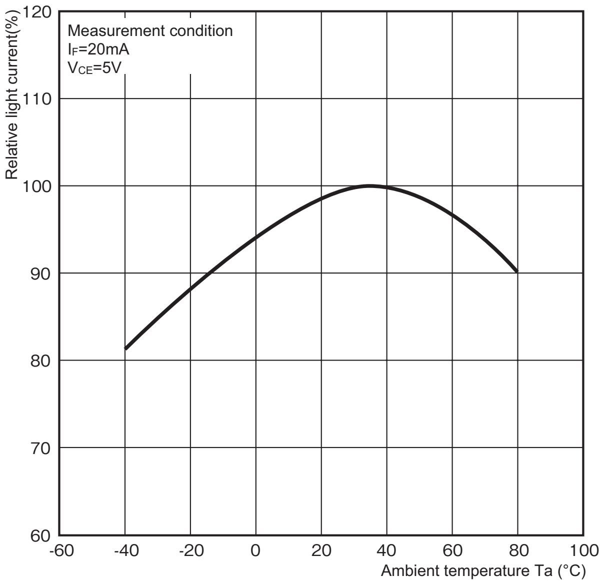
(2) Consider changes in light current due to changes in temperature and LED aging (for phototransistor output)

Shown below is the temperature dependence of the LEDs and phototransistors and their combined light current.

Temperature dependence of emitter and receiver output (Typical)



Temperature dependence of light current (Typical): EE-SX1081



Also, LEDs have the characteristic that the light emitting power decreases over time. Therefore, the light current (I_L) of phototransistors also decreases due to the decrease in light emitting power of LEDs. This means that, in addition to the aforementioned individual variations, it is also necessary to take these factors of light current fluctuation into account.
Although the aging of LEDs varies depending on the operating environment, as a guide for circuit design, it is recommended that the threshold value be set so that the sensor operates even when the light current (I_L) drops to 1/2 of the specified lower limit, in combination with the aging of LEDs over 20,000 to 50,000 hours and the change in ambient temperature.

(3) Consider changes on the equipment (for reflective type)

When a reflective sensor is incorporated in the equipment, the light current (I_L) may decrease due to changes in the amount of light reflected from the sensing object during the period the equipment is in use. You need to fully evaluate these at the time of design, and estimate and reflect the lower limit of light current (I_L) in circuit design (threshold setting).

1. When detecting different objects (e.g. color, surface condition, size)
2. Fading, soiling, and/or corrosion of sensing objects
3. Variation of sensing distance
4. Angular variation of sensing objects (especially susceptible when detecting shiny objects)
5. Dust and other contaminants entering or accumulating on the sensor's emitter/receiver

(4) Consider the effects of external disturbing light

Photomicrosensors (photo interrupters) for built-in devices are basically designed to be used in environments where they are embedded in devices and there is no external disturbing light. Therefore, it is necessary to prevent external disturbing light from entering the receiver of the sensor of the devices. If the structural design of the device does not allow sufficient light blocking, evaluate the effect of external disturbing light appropriately in the actual device, taking into consideration the installation environment of the user's device.

If you are using a reflective sensor, consider OMRON's light convergent/diffuse reflective sensor (B5W series) for built-in devices, which are equipped with a function to detect external disturbing light of a certain intensity.

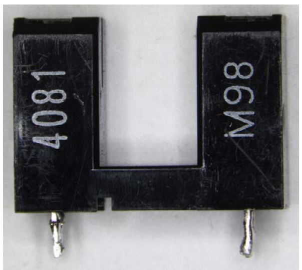
CASE 2

Malfunction due to LED open-circuit failure

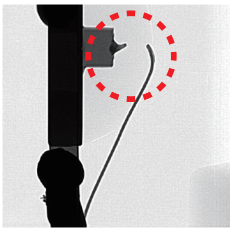
The emitter (LED) of a photomicrosensor (photointerrupter) may become open-circuit state due to the bonding wire (Au) of the LED melting with electrical stresses such as an overcurrent.

■ Malfunction case

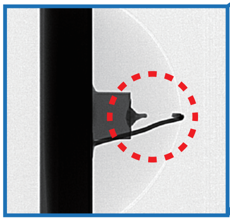
Example of open-circuit failure due to melted LED bonding wire



EE-SX4081

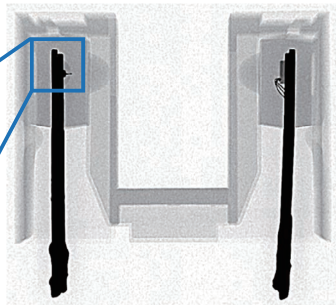


Melted Au wire (top)



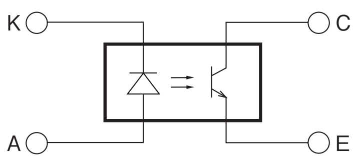
Melted Au wire (side)

Emitter (Infrared LED)



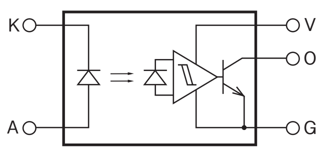
[Photomicrosensor internal circuit]

Phototransistor output type



Terminal symbol	Name
A	Anode
K	Cathode
C	Collector
E	Emitter

Photo IC output type



Terminal symbol	Name
A	Anode
K	Cathode
V	Power(V_{CC})
O	Output(OUT)
G	Ground(GND)

Probable cause of failure

Bonding wire (Au) may melt if an overcurrent of several hundred mA or more flows through it. The following are possible causes for open-circuit failure of LED elements.

(1) The supply voltage or current exceeds the specified rating.
(2) When connected without a limiting resistor for LEDs due to short-circuit caused by foreign objects or wrong wiring.
(3) Reverse voltage is applied due to wrong wiring during assembly.
(4) Power line surge.
(5) LED destroyed by static electricity during assembly.

Solution

Take the following measures for design, assembly and operation.

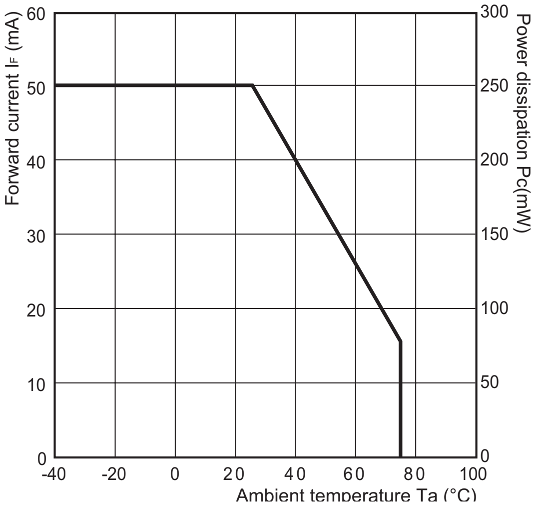
(1) Design the circuit so that it does not exceed the specified rating.

[Absolute max. rating (Ta=25°C] EE-SX4081

Item		Symbol	Rated value	Unit
Emitter				
	Forward current	I_F	50*1	mA
	Reverse voltage	V_R	4	V

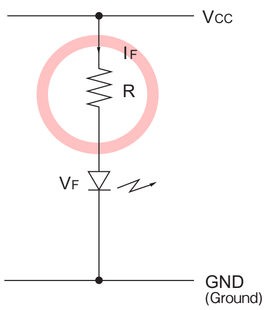
*1. If the ambient temperature is over 25°C, refer to the temperature rating chart.

[Temperature rating chart] EE-SX4081

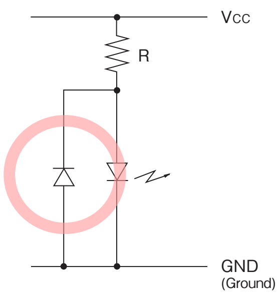


Set the LED forward current (IF) according to the temperature rating chart to match the maximum ambient temperature when the sensor is used. For details on circuit design, please refer to "Photomicrosensor Basics: Design I (Design for Emitter Side)".

(2) Be sure to insert a limiting resistor in the LED. Without a resistor, a forward bias applied to the LED, even momentarily, will result in an open-circuit failure of the LED. Check thoroughly for short-circuit caused by foreign objects and/or wrong wiring before turning on the power, even if a limiting resistor is installed on the circuit.



(3) Reverse voltage exceeding the rated voltage applied to the photomicrosensor due to wrong wiring during assembly may result in failure. If there is a possibility of reverse voltage being applied to the LEDs, including noise surges, insert a diode for rectification in reverse parallel with the LEDs.



(4) If there is a surge in the power supply line, connect a Zener diode or capacitor according to the operating environment. Confirm that the surge will go out before operation.

(5) Dielectric breakdown of LEDs may be caused by static electricity during assembly and mounting. Assemble and mount in an environment where static electricity is prevented.

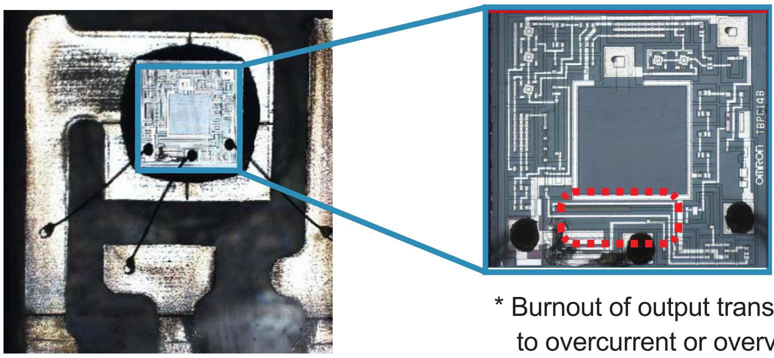
CASE 3

Malfunction due to photo IC chip circuit breakage

The receiver (photo IC) of a photomicrosensor (photointerrupter) may be broken and not operate properly due to external excessive electrical stresses being applied.

■ Malfunction case

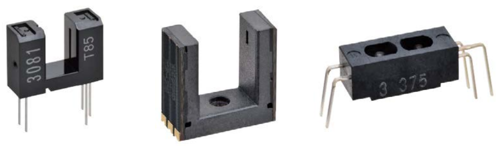
<u>**Receiver: Photo IC chip failure example**</u>

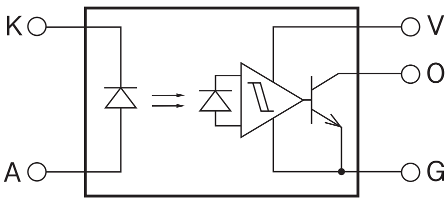


* Burnout of output transistor due to overcurrent or overvoltage

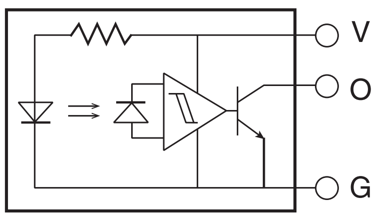
[Photo IC type photomicrosensor internal circuit]

Board mount type: EE-SX3081/4081
EE-SX3350/4350, etc.





Connector type: EE-SX316□/416□-P
EE-SX317□/417□-P, etc.



Probable cause of failure

The followings are possible causes of electrical failure of photo ICs.

(1) The supply voltage or current <u>exceeds</u> the specified <u>rating</u>.

(2) The output transistor is connected <u>without a load</u>.

(3) Reverse voltage is applied due to <u>wrong wiring</u> during assembly.

(4) Power line <u>surge</u>.

(5) There is the <u>induction from high voltage line or power line</u> which are wired parallel to the wiring of the sensor.

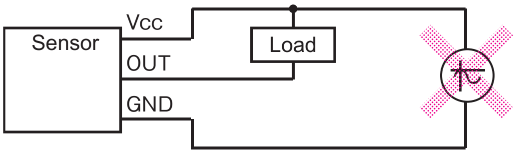
(6) A <u>small inductive load</u> such as a relay is used.

(7) Destroyed by <u>static electricity</u> during assembly.

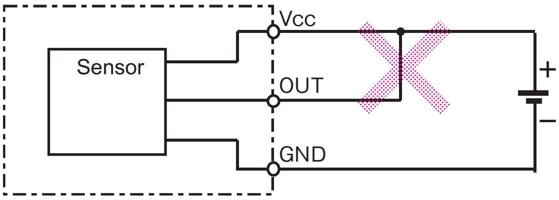
Solution

Take the following measures for design, assembly and operation (for connector type).

(1) Design the circuit so that it does not exceed the specified rating.

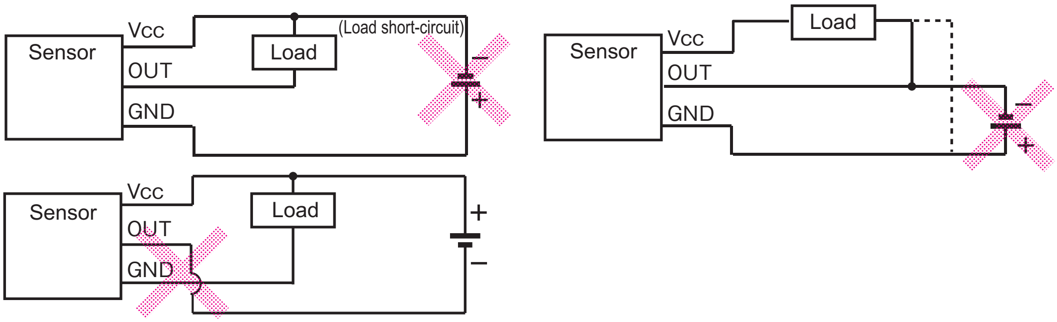


(2) As the internal element may burst or burn out, always apply a load when wiring.

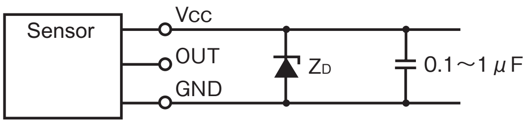


(3) If reverse voltage is applied to photomicrosensors due to incorrect wiring during assembly, such as a wrong connector type, it may cause a failure even instantaneously. Turn on the power after sufficient confirmation.

Typical example: Wrong polarity



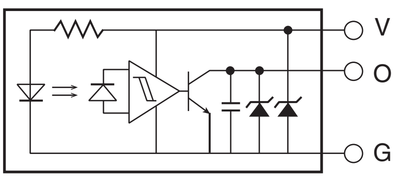
(4) If there is a surge in the power supply line, connect a Zener diode (30 to 35V) or capacitor (0.1 to 1μF) according to the operating environment. Confirm that the surge will go out before operation.



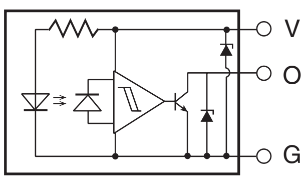
ZD : Zener diode

* Connector models with Zener diodes (EE-SX3162/4162-P1-Z and EE-SX3173/4173-P3-Z only) are also available.

EE-SX3162/4162-P1-Z

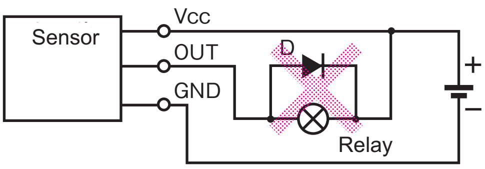


EE-SX3173/4173-P3-Z



(5) If the wiring of photomicrosensor is connected to the same wiring duct for high voltage line and/or power line, the induction may cause failure or malfunction. Use a separate wiring or a single wiring, and confirm that there is no induction.

(6) Small inductive loads such as relays cannot be used.



(7) Photomicrosensors may be damaged by static electricity during assembly and mounting. Assemble and mount in an environment where static electricity is prevented.

CASE 4

Malfunction due to external disturbing light

Photomicrosensors (photo interrupters) for built-in devices are basically designed to be used in environments where they are embedded in devices and there is no external disturbing light. Therefore, it is necessary for the device structure to prevent external disturbing light from entering the receiver of the sensor at the time of its design.

■ Malfunction case

- **The reflective sensor malfunctioned because the equipment was installed in a location exposed to direct sunlight.**
  *** Sunlight (e.g. from the west) shone on the equipment from an unexpected direction when it was installed near a window.**
- **The reflective sensor malfunctioned light from camera lighting or other sensors in the same device.**
- **The sensor malfunctioned due to reflection of external disturbing light on the light blocking plate in the groove type.**

Probable cause of failure

It may be caused by external disturbing light from inside or outside the equipment. Not only direct light from the light emitting source, but also indirect light reflected by frames and/or components inside the equipment may lead to malfunctions.

(1) Malfunction due to external disturbing light from outside the device
e.g.: Sunlight, lighting fixtures, etc.

(2) Malfunction due to external disturbing light from a light source inside the device
e.g.: lighting such as sensor cameras or other optical sensors, etc.

Solution

To avoid sensor malfunction due to external disturbing light, please consider the following measures.

(1) Review device structure
Design the structure of the device so that no external disturbing light from outside the device or from the light-emitting source inside the device enters the light-receiving surface of the photomicrosensor (photointerrupter). In particular, note that reflective sensors are more susceptible to external disturbing light than the slot sensors because they often have a larger light-receiving area and a larger light-receiving angle of incidence than the slot sensors.
You may need to consider not only direct light but also indirect light reflected by frames and/or components inside the device. This can be addressed by changing from shiny, high-reflective metal parts such as stainless steel to low-reflective materials or by applying low-reflective black tape.
If the structural design of the device does not allow sufficient light blocking for the sensor’s receiver, evaluate the effect of external disturbing light appropriately in the actual device, taking into consideration the installation environment of the user's device.

(2) Use sensors with external disturbing light avoidance
If you are using a reflective sensor, consider OMRON's light convergent/diffuse reflective sensor (B5W series) for built-in devices, which are equipped with a function to detect external disturbing light of a certain intensity.

CASE 5

Cracks or fractures in sensor case due to physical deterioration

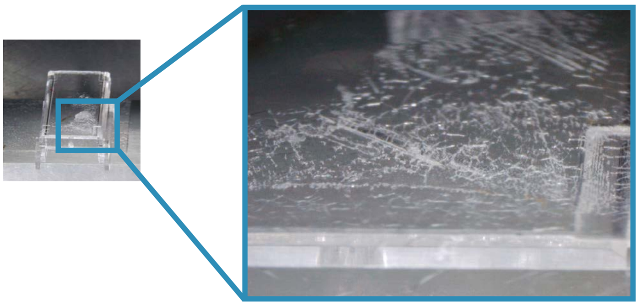
In addition to mechanical stress, adhesion of oil or solvent may deteriorate the physical properties of the photomicrosensor (photointerrupter) case, causing cracks near the screw mounting holes or micro-cracks in the transparent cover and leading to sensor failure.

■ Malfunction case

Chemical cracks caused by solvents, etc.

Micro-displacement sensor Z4D-C01

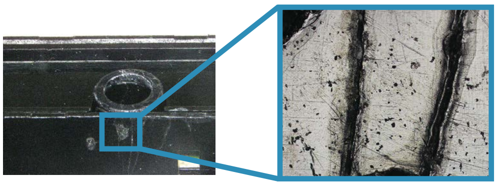
Micro-crack in transparent cover



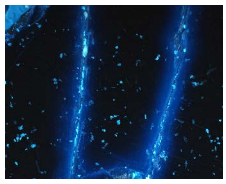
Housing cracks caused by oil, organic solvents, etc.

EE-SX4009-P10

Crack in threaded hole



UV irradiation photo



Probable cause of failure

Polycarbonate is used as the housing material for most of OMRON's built-in type photomicrosensors. Cracks in the vicinity of screw mounting holes and micro-cracks in transparent cover are generally considered to be caused by the following:

(1) Screwed with a torque exceeding the specified value.

(2) The mounting loosened and rattled due to vibration and/or impact, and mechanical stress concentrated around the screw mounting hole of the housing.

(3) Using screws or mounting brackets that are contaminated with cutting oil, etc.

(4) Organic solvents and other chemicals are used for cleaning.

Solution

Take the following measures when assembling and using a photomicrosensor (photointerrupter).

(1) Tighten the screws of built-in type photomicrosensors with tightening torque shown below. Follow the instructions in the datasheet if applicable.

Hole diameter	Screw size	Tightening torque
2.1 dia.	M2	0.34N·m
3.2 dia.	M3	0.54N·m
4.2 dia.	M4	0.54N·m

- It is recommended to use a torque screwdriver that can control the torque.
- Using 2-piece screws (set of screw and spring washer) may cause cracks in the screw mounting area. Using 3-piece screws (set of screw, spring washer, and flat washer) is recommended.

(2) Using a screw or mounting plate with cutting oil attached to it may deteriorate the properties of the housing material (mostly polycarbonate) and cause cracks in the screw mounting area due to the material used. Use completely degreased parts.

(3) Note that the following chemicals may cause degradation of properties of polycarbonate (PC).
Gasoline, thinners, toluene, cyclohexane, tetrachloroethane, cyclohexanone, trichloroethylene, acetone, xylene, benzene, turpentine oil, chloroform, formalin, ammonia, caustic oils, cutting oils, etc.

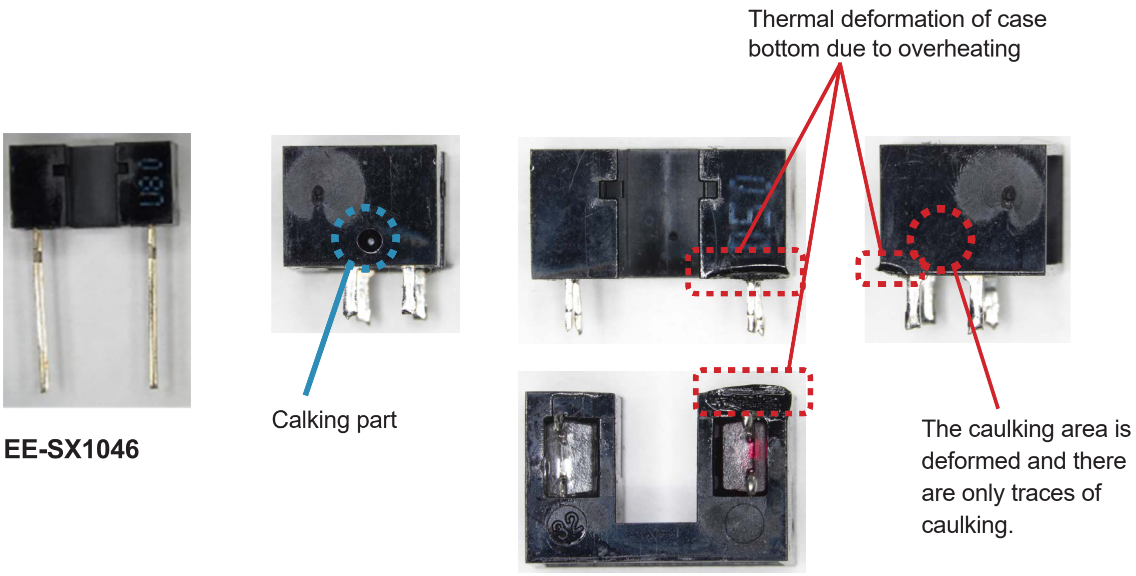
CASE 6

Element disconnection due to overheating stress

Most photomicrosensors (photointerrupters) use a cold caulking to fix the emitter and receiver. If excessive thermal stress is applied to the sensor housing during soldering, this caulking part may deform, causing the element to come loose from the housing (lifted housing after mounting on the board).

■ Malfunction case

<u>Failure example of element disconnection due to thermal deformation of caulking area</u>



Probable cause of failure

Polycarbonate is used as the housing material for most of OMRON's built-in type photomicrosensors. During soldering or other heating processes, the temperature of the caulking part exceeded the thermal deformation temperature of the plastic, which deformed the caulking protrusions that secure the emitter and receiver, resulting in reduced holding power and causing the case to be lifted after mounting on the board.

Solution

Under high-temperature environments such as in the dip soldering (flow soldering) process, be careful to control the temperature so that the absolute maximum ratings (upper storage temperature limit) of the photomicrosensors (photointerrupters) are not exceeded. In addition, the sensor housing may be deformed due to the residual heat of the board after soldering. When using a printed circuit board (e.g. glass epoxy board) with a large heat capacity, make sure the housing does not get deformed and use an appropriate cooling device if needed.
<u>In particular, be careful to control the temperature of the models (e.g. EE-SX1046) with the caulking part close to the bottom of the case as the temperature of the caulking part has a tendency to increase.</u>

Conductive error due to discoloration of lead terminals

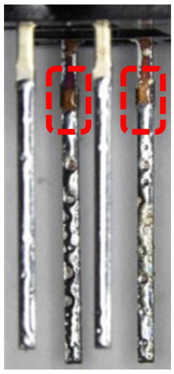
Depending on the storage conditions, photomicrosensors (photointerrupters) may become discolored due to oxidation and sulfuration. In such cases, solder wettability is reduced, which may result in conductive error after mounting.

■ Malfunction case

Decreased solder wettability due to discoloration of lead terminals

Solder wettability test result (Criteria: J-STD-002D)

- Terminal immersion in solder bath, 230˚C for 5 seconds

Before	After
	
Judgment: Bad (Criteria: J-STD-002D)	

Probable cause of failure

Most of OMRON's built-in photomicrosensors have silver plated lead terminals. The terminal color may turn black due to oxidation or sulfuration. In particular, the following storage conditions can cause discoloration:

(1) Oxidation due to storage in humid conditions

(2) Sulfuration due to sulfur component (S) contained in cardboard boxes

Solution

OMRON's photomicrosensors for built-in devices are not specially packaged to be stored for long periods of time.
Since long-term storage may cause deterioration of solderability due to discoloration of lead terminals, use the product as soon as possible after purchase.
Store the product in a place that is not affected by high temperature, humidity, or corrosive gas. The following measures are required to prevent corrosion from long-term storage:

・Put in an aluminum laminate film bag and seal it.

・Put desiccating agent such as silica gel in a thick nylon bag and seal it.

Note that generally available cardboard boxes are not recommended for storage due to concerns about sulfur content (S) and residual acidity during processing.

CASE 8

Malfunction due to mutual interference

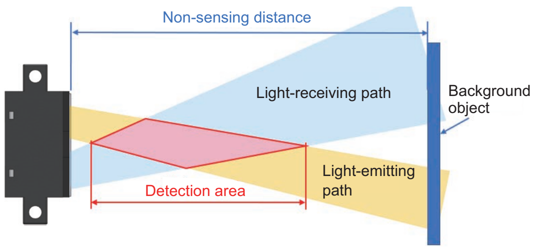
OMRON's light convergent/diffuse reflective sensors B5W series use a modulated light (pulse-lighting) method to detect objects with low reflectance and long distances. Since the sensing distance is longer than that of a photomicrosensor, mutual interference may cause the sensor to malfunction when multiple sensors are installed in a device or equipment.

■ Malfunction case

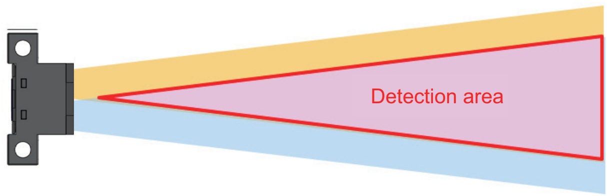
- **Sensor output is light-receiving state even when there is no object to be detected.**
- **Sensor output becomes unstable regardless of the presence or absence of sensing objects.**
- **Sensor output is always in the light-receiving state.**

[Light emitting/receiving path of light convergent/diffuse reflective sensor]

Light convergent reflective sensor



Diffuse reflective sensor



Probable cause of failure

Mutual interference refers to the unstable operation of multiple sensors installed side by side due to the influence of light from adjacent sensors. This occurs when the sensors' pulse-lighting timings match. Assuming adjacent sensors as Sensor A and Sensor B, respectively, Sensor B may malfunction due to mutual interference in the following cases.

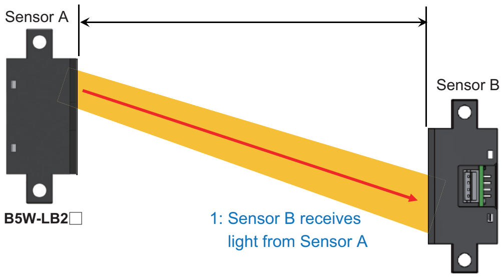
(1) When the light from Sensor A enters Sensor B directly (installed facing each other)

(2) When the light from Sensor A enters Sensor B after being reflected by a detected object (e.g. parallel installation)

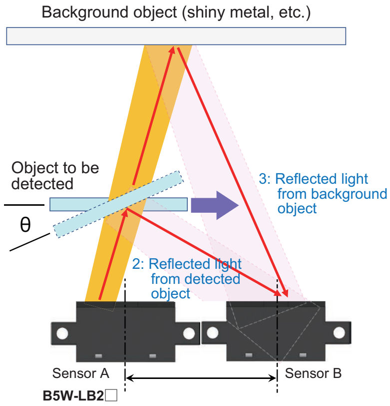
* The detected object may be tilted, or the object shape is not flat (e.g. spherical).

(3) When the light from Sensor A enters Sensor B after being reflected by a background object (e.g. parallel installation)

[Example of mutual interference when installed facing each other]



[Example of mutual interference in parallel installation]



Solution

OMRON's light convergent/diffuse reflective sensors are designed using an optical lens with high luminous flux density. Therefore, to avoid mutual interference while using multiple sensors, the location of the sensor and the structure of the equipment must be designed to prevent the following light from entering the sensor:

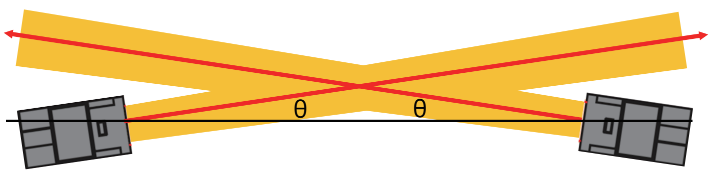
① Direct light from other sensors

② Indirect light from other sensors reflected by a sensing object or background object

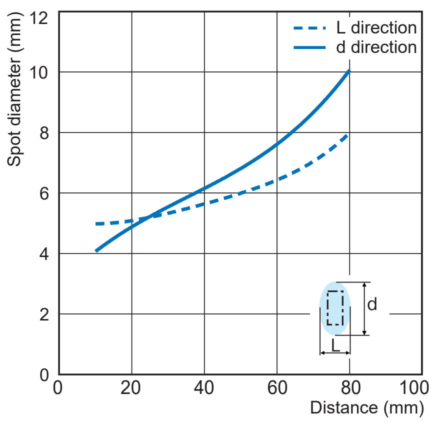
(1) When installed facing each other

When this sensor is installed facing another sensor, the light from the sensor may enter the other sensor opposite, even if the sensors are installed beyond the specified non-sensing distance. As a countermeasure, mutual interference can be avoided by installing the sensors at an angle to each other, taking into account the light spread from this sensor (see figure below). Use the actual device to check the sensor's light spread while referring to the charts of spot diameter - distance and operating range characteristics shown in the datasheet.

[Example of countermeasure: Shift the beam on installation]



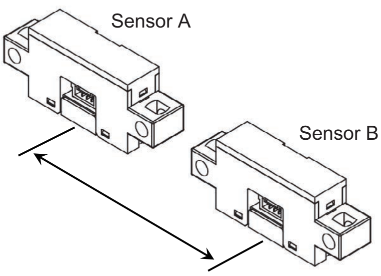
■ Spot diameter - distance characteristics: B5W-LB2□



(2) When installed in parallel

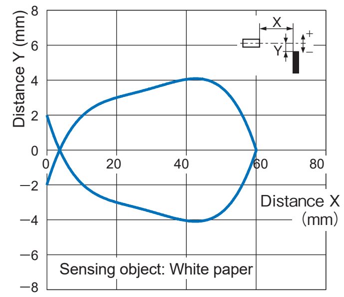
Basically, install adjacent sensors at a distance that does not interfere with each other. Check the sensor's light spread while referring to the charts of spot diameter - distance and operating range characteristics shown in the datasheet.

■ Parallel installation: A

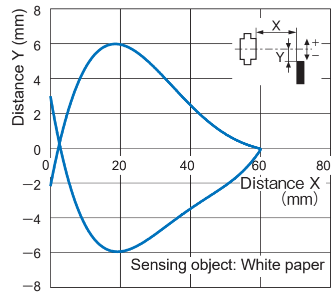


■ Operating range characteristics: B5W-LB2□

Left and right

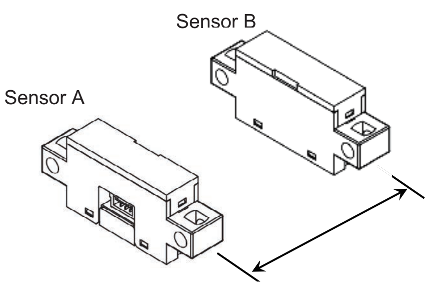


Up and down

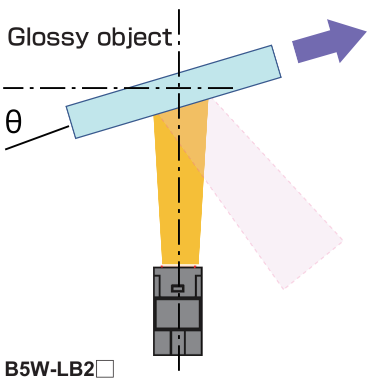


As shown above in [Example of mutual interference in parallel installation], the emitting beam of the light convergent reflective sensor is tilted.
Therefore, consider that there may be interference with adjacent sensors depending on the angle and shape of the sensing object and the positional relationship between each sensor and the background objects.
In particular, keep in mind that if a background object is highly reflective, such as a shiny metal, there may be mutual interference even if the distance is greater than the specified sensing distance. Countermeasures include drilling holes in the background object to prevent light from reflecting off it, or applying stickers with low reflectance (e.g. black, rough surface).
Taking into account the angle of the beam of this sensor, consider rotating the sensor 90 degrees with respect to the parallel installation: A. Further improvement can be achieved by rotating Sensor B 180 degrees relative to Sensor A, as shown in the figure below.

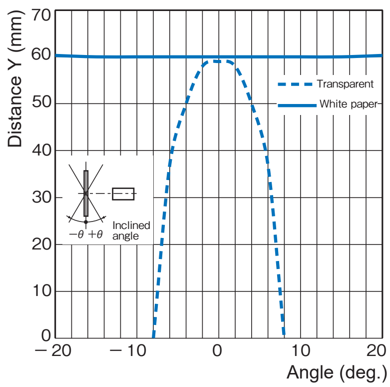
■ Parallel installation: B



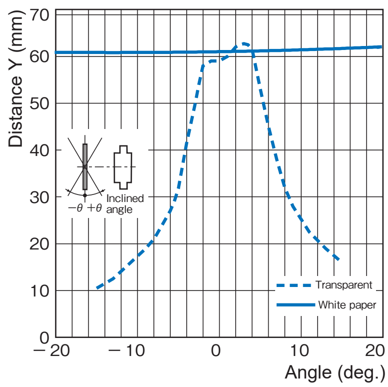
Caution
When the sensor is installed with a certain angle to avoid mutual interference in installation of either facing each other or in parallel, if the sensing object is a shiny one such as a glass plate or film, the reflected light may not enter the sensor which may not be able to detect the object (see figure below). For the installation angle of the sensor, refer to the graph of angular characteristics in the datasheet and be sure to evaluate the sensor on the actual device.



■ Angular characteristics (left and right): B5W-LB2112/LB2122



■ Angular characteristics (up and down): B5W-LB2112/LB2122



(3) If mutual interference cannot be avoided due to the structural design of the equipment, consider a photoelectric sensor with a mutual interference prevention function.

CASE 9

Malfunction due to transparent cover

When incorporating OMRON's light convergent/diffuse reflective sensors B5W series into a device, a transparent cover may be installed in front of the sensor to protect the device from dust and water and to flatten the device surface (for cleaning purposes). The sensor may not operate properly with this type of use.

■ Malfunction case

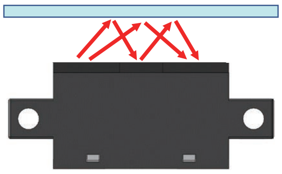
- ◆ **Sensor output is always in the light receiving state regardless of the presence or absence of sensing objects.**
- ◆ **When the transparent cover is contaminated with adhesives or scratches, the sensor output will be in the light-receiving state.**

Probable cause of failure

OMRON's light convergent reflective sensors have optical characteristics that enable detection even on transparent objects such as glass plates and films.
Depending on the installation distance and thickness of the transparent cover (plate) installed in front of the sensor as shown below, its reflected light may enter the sensor and cause it to malfunction.

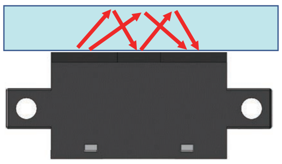
(1) Effect of reflected light on the inner surface of the transparent cover

■ When the distance between the sensor and the transparent cover is far



(2) Effect of internally reflected light on the outer surface of the transparent cover

■ When the transparent cover is thick



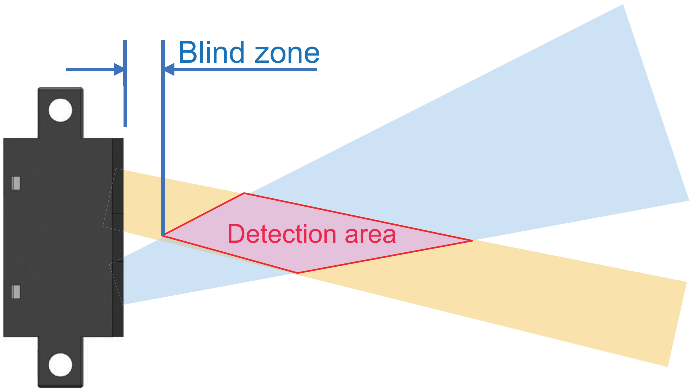
Solution

When installing a transparent cover on the front of OMRON's light convergent/diffuse reflective sensors B5W series, note the following and thoroughly evaluate whether the sensor will operate properly on the actual device before use.

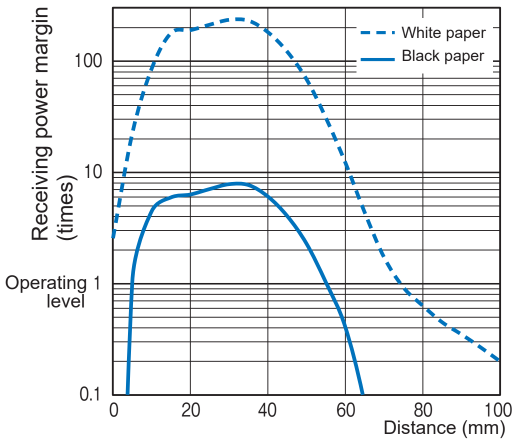
(1) To avoid the effect of reflected light from the transparent plate, <u>the plate should be installed in the blind zone near the light emitting and receiving surfaces of the sensor (close mounting)</u>

(2) To avoid the effect of reflected light from the transparent plate, <u>the plate should be as thin as possible</u>.

[Blind zone of light convergent reflective sensor]



■ Receiving light output - Sensing distance:
B5W-LB2112/2122



Furthermore, keep the following in mind and confirm that the sensor operates properly for the intended sensing object through the cover when evaluating the actual device.

- Variation in assembly of sensor and transparent cover
- Scratches and deposits on the transparent cover expected during use

Test data on the impact of transparent cover

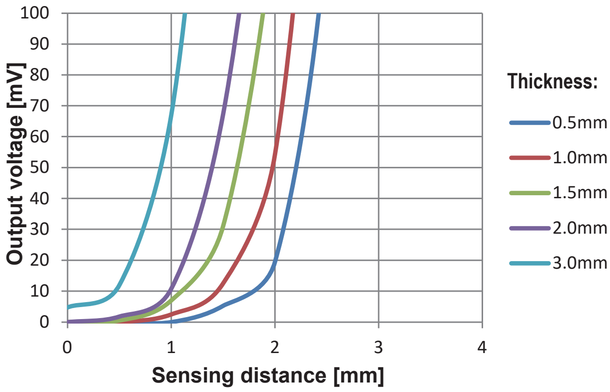
Described below is the test data on the effect of a transparent plate near the blind zone of the sensor.
The actual environment may vary and this data is for reference only. You need to evaluate the effect on the actual device.

■ Light convergent reflective type sensor: B5W-LB2101 (analog output type)

The test results show that the smaller (1) the distance between the sensor and the transparent plate and (2) the cover thickness, respectively, the smaller the output voltage (the amount of light received due to the effect of the transparent cover) of the sensor.

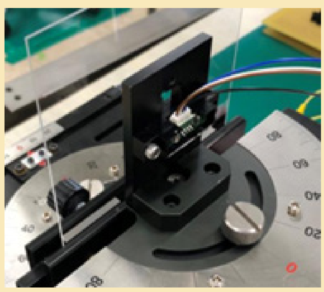
Measurement result

Distance between sensor and transparent plate	Thickness [mm]	Output voltage [mV]				
		t=0.5	t=1.0	t=1.5	t=2.0	t=3.0
0	mm	0.0	0.0	0.0	0.0	4.8
0.5	mm	0.0	0.0	0.5	1.8	12.0
1	mm	0.0	2.5	7.0	10.8	67.0
1.5	mm	5.3	12.5	31.0	67.3	212.3
2	mm	19.5	54.3	129.0	191.8	316.8
2.5	mm	124.8	217.8	300.5	336.3	432.5
3	mm	373.0	432.0	497.3	524.0	628.0
3.5	mm	595.0	644.0	697.5	754.5	834.0
4	mm	735.0	794.5	848.3	896.5	968.5
4.5	mm	913.0	956.0	1000.5	1047.5	1119.0
5	mm	1053.3	1094.5	1139.5	1187.0	1252.0

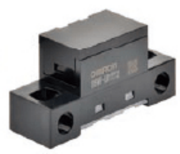


[Measurement conditions]
Measure the output voltage at the distance (0 - 5 mm) between the sensor and the transparent plate.

- Sensing object: Transparent plate (PMMA) Thickness: 0.5, 1.0, 1.5, 2.0, 3.0 mm
- Supply voltage: 5.0V
- Pulse cycle: 2000μs
- Pulse width: 800μs
- Number of samples: n=4 (Data values are averages)



■ Light convergent reflective sensor: B5W-LB11□□

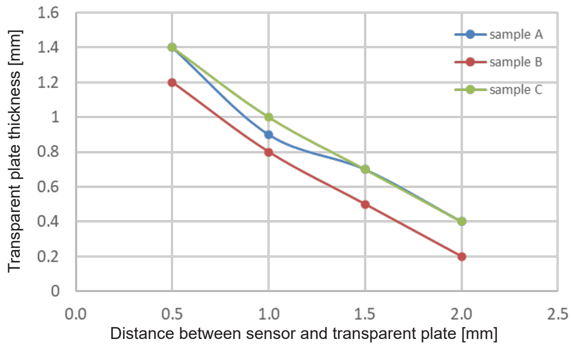


Unlike the analog output type sensor, the ON/OFF output type sensor cannot measure the amount of light received by the sensor using output voltage. Thus, it measures the sensing distance (the distance at which the sensor operates when the sensing object is brought close to the sensor). The test results show the relationship between sensing distance and transparent plate thickness. Compared to the B5W-LB21□□, this product is smaller, has a closer distance between the emitting and receiving elements, and has a smaller blind zone.

Measurement result

Transparent plate thickness [mm]]	Sensing distance		
	sample A	sample B	sample C
t = 0.5	1.4 mm	1.2 mm	1.4 mm
t = 1.0	0.9 mm	0.8 mm	1.0 mm
t = 1.5	0.7 mm	0.5 mm	0.7 mm
t = 2.0	0.4 mm	0.2 mm	0.4 mm
t = 3.0	×	×	×

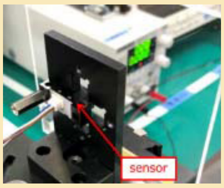
x indicates that the transparent object is detected even if it is close contact with the sensor.



[Measurement conditions]

The transparent plate is moved closer to the sensor and the distance at which the sensor operates (sensing distance) is measured.

- Sensing object: Transparent plate (PMMA)
  Thickness: 0.5, 1.0, 1.5, 2.0, 3.0 mm
- Supply voltage: 24.0V
- Number of samples: n=3

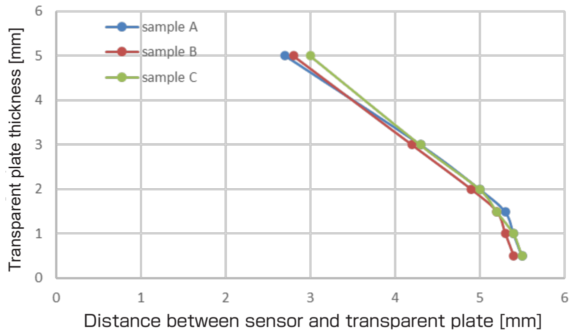


■ Diffuse reflective sensor (variable distance type): B5W-DB11A1-A

As with the light convergent reflective sensor, the sensing distance is measured using transparent plates with the diffuse reflective sensor. As the diffuse reflective sensor has a slightly wider blind zone than the light convergent reflective sensor due to its optical design, transparent plates up to 5 mm in thickness are used for measurement.
Here are the test results for the variable distance type with high LED current flow (external limiting resistor value: R2=0Ω).

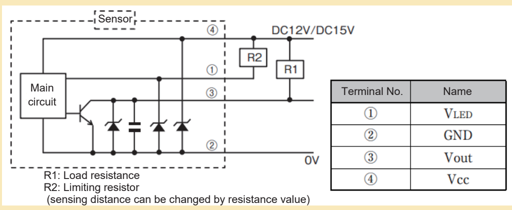
Measurement result

Transparent plate thickness [mm]	Sensing distance		
	sample A	sample B	sample C
t = 0.5	5.5 mm	5.4 mm	5.5 mm
t = 1.0	5.4 mm	5.3 mm	5.4 mm
t = 1.5	5.3 mm	5.2 mm	5.2 mm
t = 2.0	5.0 mm	4.9 mm	5.0 mm
t = 3.0	4.3 mm	4.2 mm	4.3 mm
t = 5.0	2.7 mm	2.8 mm	3.0 mm



[Measurement conditions]
The transparent plate is moved closer to the sensor and the distance at which the sensor operates (sensing distance) is measured.

- Sensing object: Transparent plate (PMMA)
  Thickness : 0.5, 1.0, 1.5, 2.0, 3.0, 5.0 mm
- Supply voltage: 12V
- LED external limiting resistor value: R2 = 0 Ω
- Number of samples: n=3



CASE 10

Malfunction due to tilted shiny object

When OMRON's light convergent reflective sensor B5W-LB series is used to detect a shiny object such as a mirror or glass plate, the amount of light entering the sensor may be significantly reduced due to the inclination of the object, resulting in failure of detection. The angle at which the glossy object is placed should be noted.

■ Malfunction case

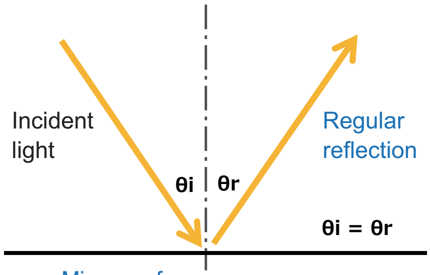
- ◆ **Sensing object cannot be detected.**
- ◆ **Detection is not stable if the sensing object flops.**

Probable cause of failure

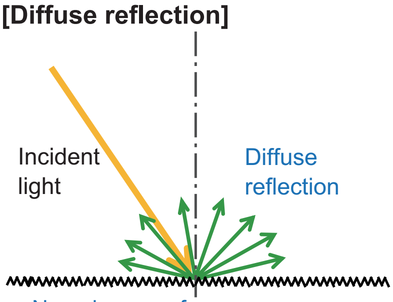
Diffuse reflection and regular reflection

Reflections include both regular and diffuse reflections. If the sensing object is a mirror surface, light received at an angle of incidence (θi) will be reflected at the same angle. This is the regular reflection. And on non-glossy (rough) surfaces, reflected light is diffused at various angles. This is the diffuse reflection. In general, the reflected light from a sensing object is a mixture of regular and diffuse reflections, with a high gloss surface having more regular reflection light.

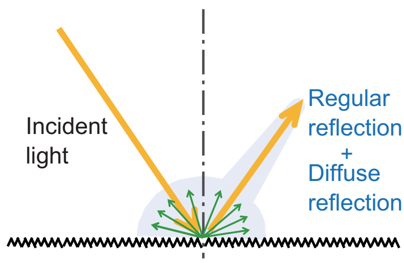
[Regular reflection]



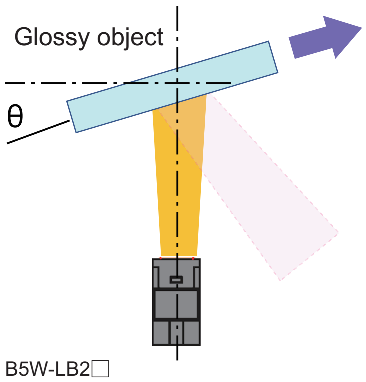
[Diffuse reflection]



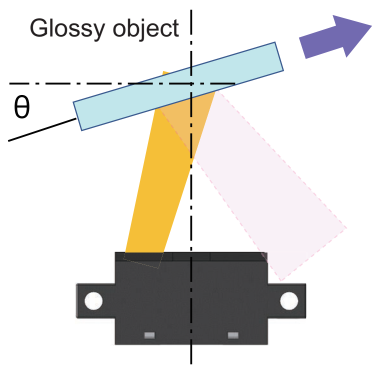
Reflected light from glossy surface



OMRON's light convergent reflective sensor B5W-LB series is designed to detect even objects with low reflectance by narrowing the optical path to capture directly reflected light. Especially when a glossy object such as a glass plate should be detected, the receiving light intensity of the sensor significantly varies depending on the angle of the object's glossy surface.
When the object to be detected is a shiny object (especially a mirror surface), and if the detection surface is tilted toward the sensor, no directly reflected light will enter the sensor and the object may not be detected (see the figure below).

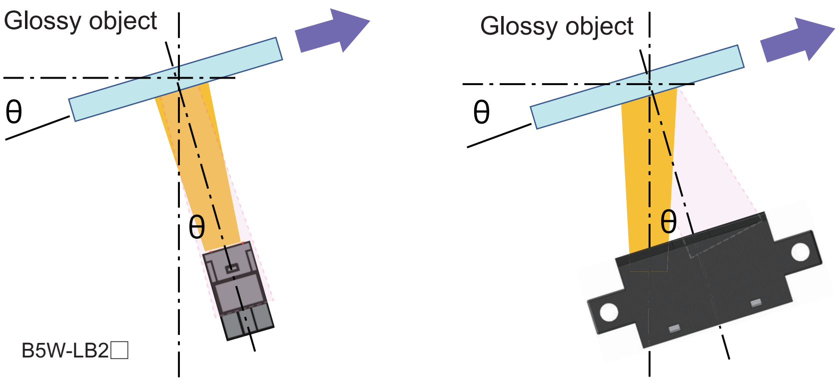


B5W-LB2□



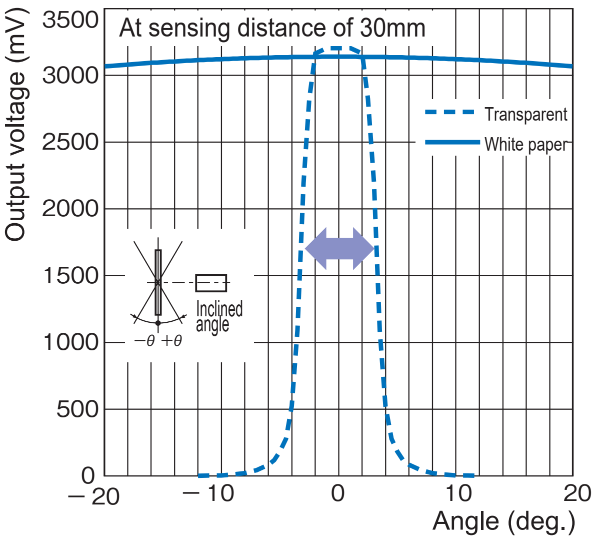
Solution

As mentioned before, OMRON's light convergent reflective sensor B5W-LB series has an optical design that captures the regular reflection light. To detect a glossy object, it is recommended to design the equipment so that the detection surface is basically parallel to the sensor's light emitting and receiving surfaces. If the detection surface is inclined to the sensor due to the structure of the equipment, the problem can be solved by tilting the sensor (see the figure below).

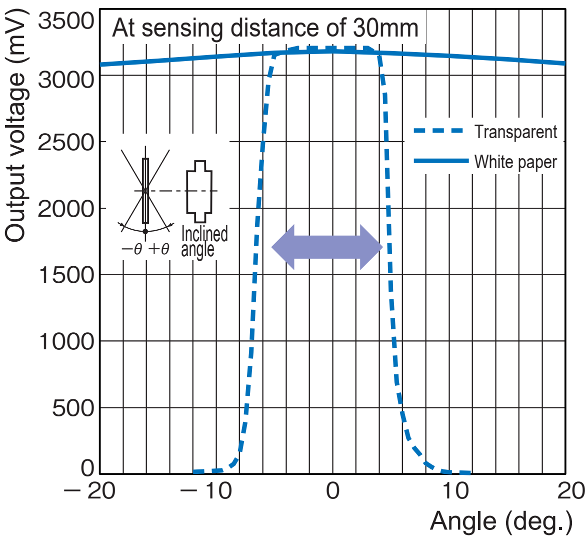


If the inclination of the sensing object varies due to assembly variations in equipment design or due to the flutter of the sensing object, refer to the angular characteristics shown in the data sheet. The tolerance to the inclination of a sensing object should be appropriately evaluated using actual equipment.

■ Angular characteristics (left and right): B5W-LB2101



■ Angular characteristics (up and down): B5W-LB2101



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