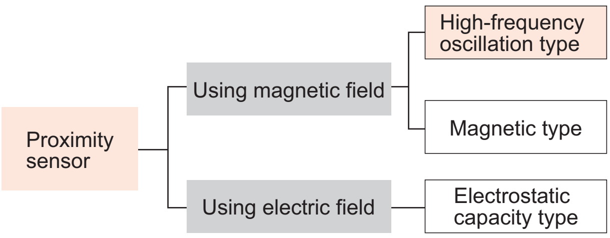
INTRODUCTION

Principles of operation

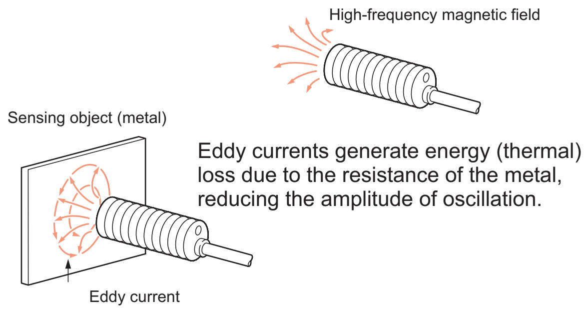
- A proximity sensor detects the approach of an object without making a contact. There are three types of proximity sensors:
  1) High-frequency oscillation type using electromagnetic induction
  2) Magnetic type using magnetism
  3) Electrostatic capacity type which senses the changes in the electrostatic capacity between the sensing object and the sensor.

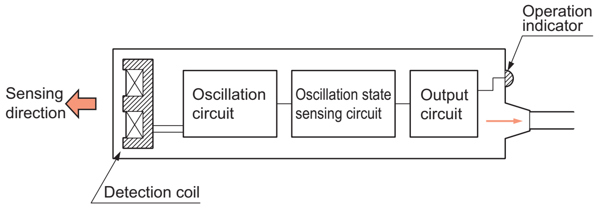


Panasonic Electric Works SUNX proximity sensors are high-frequency oscillation type inductive proximity sensors.

Principle of high-frequency oscillation type inductive proximity sensor

- The detection coil located at the front end of the sensor produces a high-frequency magnetic field as shown in the figure below. When an object (metallic) approaches this magnetic field, induced currents flow in the metal, causing thermal loss and resulting in the reduction or stopping of oscillations.
  This change in state is detected by an oscillation state sensing circuit which then operates the output circuit.





FEATURES

Non-contact detection

- Unlike a limit switch, it detects an object without any mechanical contact. Hence, there is no likelihood of the sensing object or the sensor getting damaged by contact.

Usable in severe environment

- Reliable sensing is possible even in adverse conditions where it can come in contact with water, etc. Most of the sensors have IP67 protection and oil resistant construction.

High precision

- It is suitable for precise object positioning because of its very high repeatability.

Short response time

- Stable detection is possible even with fast traveling objects because of its high response frequency (3.3 kHz max.).

Long life

- Due to its non-contact output, it has a long life and requires practically no maintenance.

* However, it also has the following disadvantages.

Only metal detection

- It cannot detect non-metals in which current cannot flow, since detection is based on thermal loss due to induced current.
  (Also, metals such as ferrite, which do not allow current flow, cannot be detected.)

Short sensing range

- Although there are several methods for improving the sensing range, such as increasing the detection coil size, using non-shielded sensor heads, etc., the sensing range is still smaller than that of photoelectric sensors.

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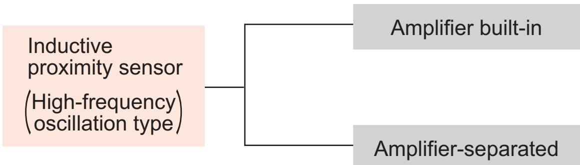
Method of classification

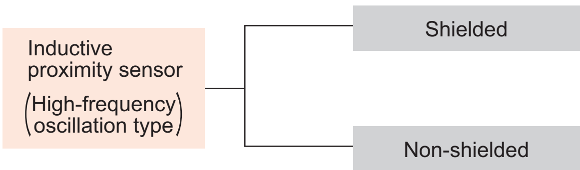
① Classification by structure

- This classification is based on whether the constituent circuit elements are built-in or separated. It is useful for selecting sensors in view of the mounting space, power supply, and noise immunity.



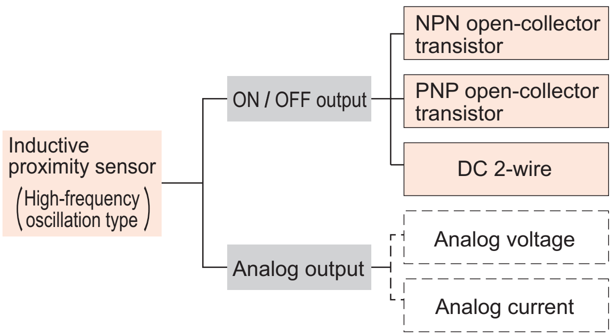
② Classification by coil enclosure

- This classification is based on the structure surrounding the sensor head (detection coil). It is useful for selecting sensors in view of the mounting style, sensing range, influence of surroundings, etc.



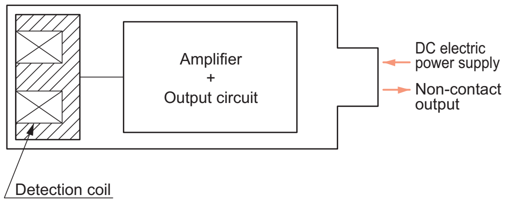
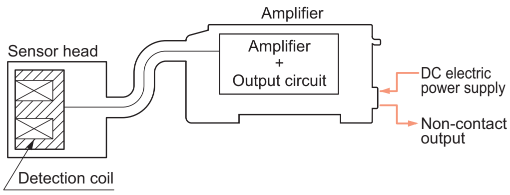
③ Classification by output circuit

- 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.



Classification

① Classification by structure

Type	Outline and Features
Amplifier built-in	• As the amplifier is built-in, a non-contact output is obtained simply by connecting a DC electric power supply. • It has high noise immunity because the amplifier is built-in. 
Amplifier-separated	• The sensing portion can be made small since the detection coil is separated as the sensor head. (However, its noise immunity is less than that of the amplifier built-in type.) • The sensitivity setting can be done on the amplifier at a remote place. 

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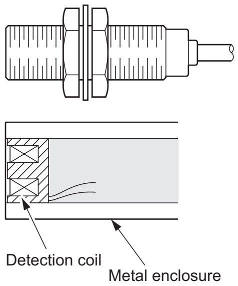
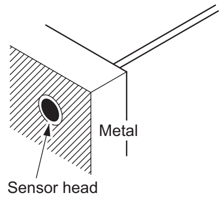
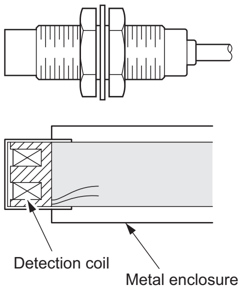
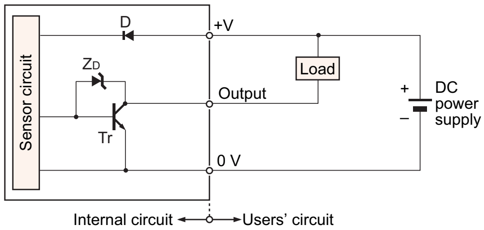
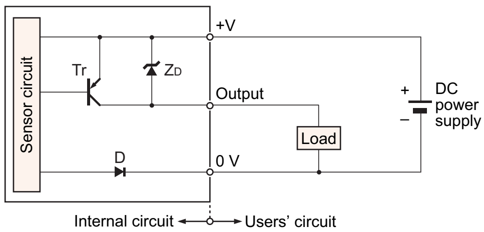
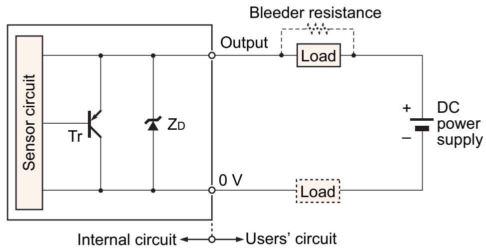
TYPES OF SENSORS

② Classification by coil enclosure

Type	Outline and Features
Shielded	 • A metal enclosure shields the sides of the detection coil. • The sensor can be embedded in metal as it is less affected by the surrounding metal. (**GX-3S□**, **GX-4S□**, **GX-5S□** and **GX-5SU□** require a small clearance at the front sensor end.) 
Non-shielded	 • The sides of the detection coil are not shielded by a metal enclosure. [All resin-enclosed sensors (**GX-F/H** series, **GXL** series, **GL** series) are non-shielded types.] • They have a longer sensing range than a shielded type of the same size. • Since it is easily affected by surrounding metal, care should be taken that metal other than the sensing object does not come near the sensor front end.

③ 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
ON / OFF output	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 the model.) ZD: Surge absorption zener diode (Its position differs with the model.) Tr : PNP output transistor

Type		Outline and Features
ON / OFF output	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

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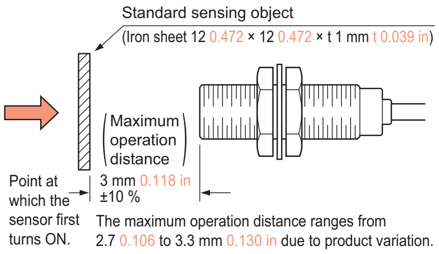
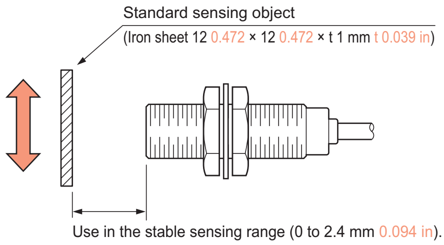
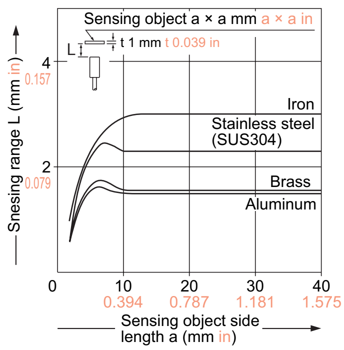
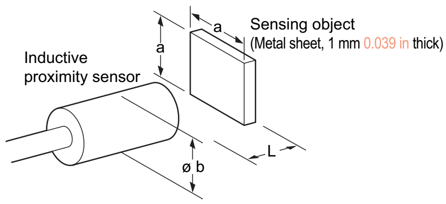
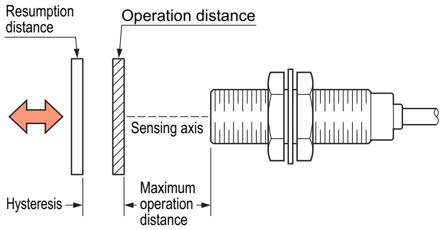
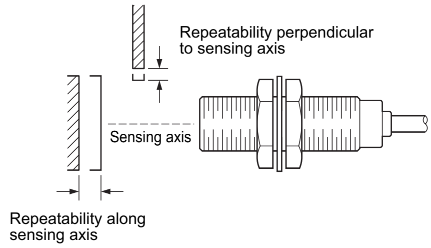
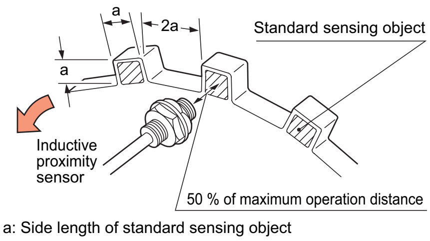
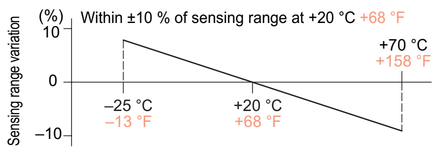
<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>Maximum operation distance</td><td>It is the distance to the point at which the sensor first detects the standard sensing object as it slowly approaches the sensing head as shown in the figure below.
Example: In case of GX-12MU
</td></tr>
<tr><td>Stable sensing range</td><td>It is the sensing range for which the sensor can stably detect the standard sensing object even if there is an ambient temperature drift and/or supply voltage fluctuation.
(Normally, it is 70 to 80 % of the maximum operation distance.)
Example: In case of GX-12MU
</td></tr>
<tr><td>Standard sensing object</td><td>It is the smallest size object for which the sensing range becomes constant. The sensing range, hysteresis, etc., are all specified for the standard sensing object. The material of the standard sensing object is iron.
• Reference for the size of the standard sensing object (a × a mm a × a in)
Shielded type: Approx. equal to the size (b) of the sensing portion.
Non-shielded type: Approx. equal to 1.5 times the size (b) of the sensing portion.
Correlation between sensing object size and sensing range

</td></tr>
<tr><td>Hysteresis</td><td>For a sensor, the hysteresis is the difference between the operation distance, when the first action is taken with the standard sensing object approaching along the sensing axis, and the resumption distance, when the first action is taken with the standard sensing object receding. It is expressed as a percentage of the operation distance. Normally, a hysteresis of 10 to 20 % of the maximum operation distance is incorporated to prevent chattering of the output due to vibration, etc., of the sensing object.
</td></tr>
<tr><td>Repeatability</td><td>Variation in the sensor operation point when sensing is repeatedly done under constant conditions.
</td></tr>
<tr><td>Maximum response frequency</td><td>As shown in the figure below, a rotating plate having the standard sensing object pasted at constant intervals is placed in front of the proximity sensor. The plate is rotated while observing the sensing output. The maximum number of times per second at which sensing can be done, for which the corresponding sensing output can be obtained, is the maximum response frequency.

a: Side length of standard sensing object</td></tr>
<tr><td>Sensing range variation
(temperature characteristics)</td><td>It is the change in the sensing range, with respect to the sensing range at +20 °C +68 °F, when the ambient temperature is varied over the rated ambient temperature range.
Example: In case of GX-U/N series
</td></tr>
<tr><td>Sensing range variation
(voltage characteristics)</td><td>It is the change in the sensing range with respect to the sensing range at a particular supply voltage when the supply voltage varies by ±10 %.</td></tr>
</table>

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).

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) — ø50 ø1.969
2	Protection against contact with internal live parts by a human finger (ø12 mm ø0.472 in) — ø12 ø0.472
3	Protection against contact with internal live parts by a solid object more than 2.5 mm 0.098 in in thickness or diameter — t 2.5 t 0.098
4	Protection against contact with internal live parts by a solid object more than 1.0 mm 0.039 in in thickness or diameter — t 1.0 t 0.039
5	Protection against dust penetration which can affect operation
6	Complete protection against dust penetration

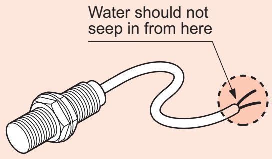
Note: The IEC standard prescribes test procedures for each protection degree given above. The protection degree specified in the product specifications has been decided according to these tests.

• 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 — 15° 15°
3	No harmful effect due to water drops falling from a range 60° wider than the vertical — 60° 60°
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.



JEM standards (Standards of the Japan Electrical Manufacturer's association)

• 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.

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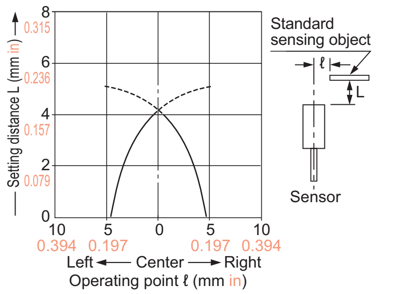
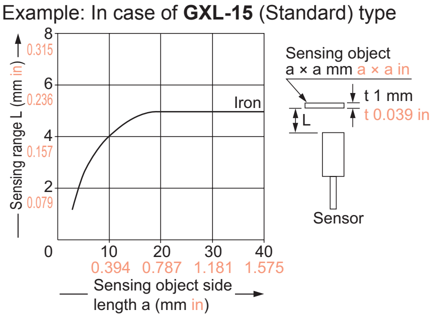
Term	Description
Sensing field	The curves are plotted as a series of operating points at which the sensor detects the standard sensing object as it approaches from the left or the right for different setting distances (with the sensitivity adjuster at maximum sensitivity). The graph is useful to determine the mounting position of the sensor with respect to the sensing object. (The graph shows typical characteristics. There could be slight variation depending on the product.) Example: In case of **GXL-15** (Standard) type 
Correlation between sensing object size and sensing range	The graph shows 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. (The graph shows typical characteristics. There could be slight variation depending on the product.) Example: In case of **GXL-15** (Standard) type 

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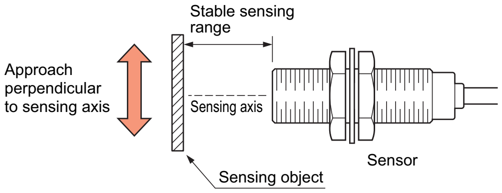
Setting distance

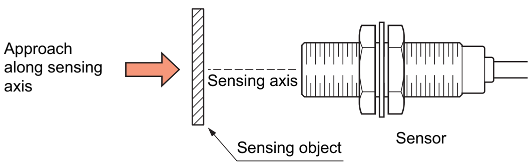
Approach perpendicular to sensing axis

- Normally the sensor is used with the sensing object approaching from a direction perpendicular to the sensing axis. Adjust the distance to the sensing object to be within the stable sensing range which is slightly less than the maximum operation distance.



Approach along sensing axis

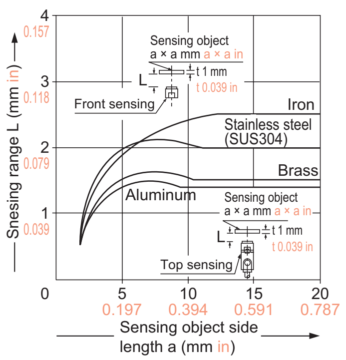
- When the sensing object approaches the sensor along the sensing axis, it is detected at the maximum operation distance.
  However, make sure to avoid any collision between the sensing object and the sensor, which may occur due to the sensing object speed.



Type of metal objects and sensing range

- The sensing range is specified for the standard sensing object. If the sensing object is smaller, or is non-ferrous, the sensing range shortens.

Correlation between sensing object size and sensing range (In case of GXL-8 type)



Correction coefficient for different sensing object materials (In case of GXL-8 type)

Sensing object	Correction coefficient
Iron	1
Stainless steel (SUS304)	0.82 approx.
Brass	0.59 approx.
Aluminum	0.57 approx.

Note: The sensing range also changes if the sensing object is plated.

Mounting

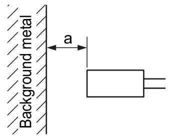
Influence of surrounding metal

- Surrounding metal may affect the performance of the inductive proximity sensor. Keep the specified distance between the surrounding metal and the sensor.

(For details, refer to the section "**PRECAUTIONS FOR PROPER USE**" of each sensor.)

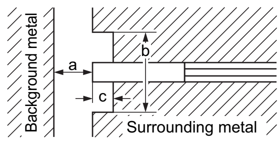
<Cylindrical type and threaded (shielded) type>

Beware of background metal



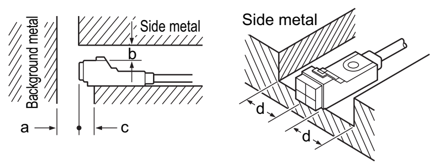
<Threaded (non-shielded) type>

Beware of background and surrounding metal



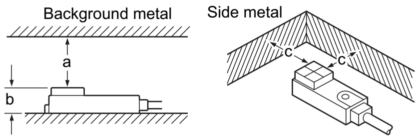
<Top sensing (non-shielded) type>

Beware of background and side metal



<Front sensing (non-shielded) type>

Beware of background and side metal

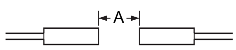


Mutual interference

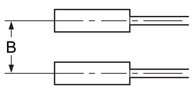
- When several inductive proximity sensors are mounted close together, the high frequency magnetic field emanating from one sensor exerts an electromagnetic influence on the other sensors, mutually causing their operation to become unstable (called mutual interference). In this case, the following countermeasures are necessary.

Countermeasures ①: Keep sufficient spacing.

Face to face mounting

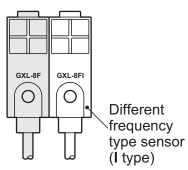


Parallel mounting



(For details, refer to the section "**PRECAUTIONS FOR PROPER USE**" of each sensor.)

Countermeasures ②:
When used along with a different frequency type (**I** type), in which the oscillation frequency is different, two sensors can be parallely mounted next to each other.



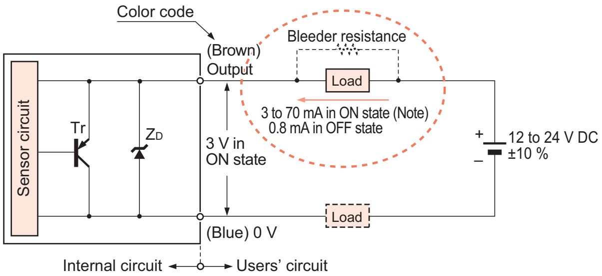
PRECAUTIONS FOR PROPER USE

Bleeder resistance setting procedures

- The DC 2-wire type inductive proximity sensors manufactured by Panasonic Electric Works SUNX do not normally function in the case where the load current is under 3 mA when the load is connected to the output. In that case, it is necessary for a load current of 3 mA or more to flow by connecting the load to the resistance in parallel. This resistance is called “bleeder resistance”.

  The I/O circuit diagram of the DC 2-wire type inductive proximity sensors is described as below.

I/O circuit of DC-2 wire type



Symbols … Z_D: Surge absorption zener diode
Tr : PNP output transistor

Note: The maximum load current varies depending on the ambient temperature.

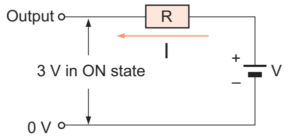
Conditions for the load

1) The load should not be actuated by the leakage current (0.8 mA) in the OFF state.
2) The load should be actuated by (supply voltage – 3 V) in the ON state.
3) The current in the ON state should be between 3 to 70 mA DC.

In case the current is less than 3 mA, connect a bleeder resistance in parallel to the load so that a current of 3 mA, or more, flows.

● Examine the necessity for bleeder resistance

First, examine if bleeder resistance is necessary when connecting the load to the output.

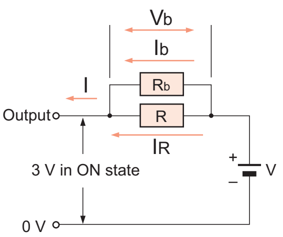


Provided that load is “R”, load current is “I”, supply voltage is “V”, and output residual voltage is 3 V, you can calculate the load current “I” when output is in the ON state using the following formula.

$$I = \frac{V - 3\ [V]}{R\ [k\Omega]}\ [mA]$$

The DC 2-wire type inductive proximity sensors manufactured by Panasonic Electric Works SUNX do not need bleeder resistance when I ≥ 3 mA, but need it when I < 3 mA.

● Calculation method of the necessary bleeder resistance



Provided that bleeder resistance is “R_b”, electric current flowing to “R_b” is “I_b”, voltage within R_b is “V_b”, electric current flowing to R is “I_R”, load current to the sensor is “I”, and supply voltage is “V”;

$I = I_R + I_b = 3$ [mA] or more
$V_b = R_b \times I_b = R \times I_R$
$= V - 3$ [V]

the relational expression above is formulated.

The bleeder resistance R_b and bleeder resistance power P_b can be calculated using the formula below.

$$R_b = \frac{V_b}{I_b} = \frac{V - 3\ [V]}{I - I_R\ [mA]} = \frac{V - 3\ [V]}{3 - I_R\ [mA]}\ [k\Omega] \text{ or less}$$

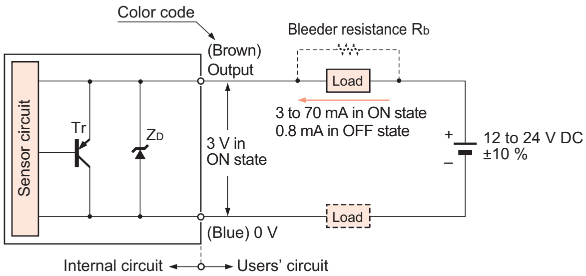
$$P_b = V_b \times I_b = \frac{V_b^2\ [V]}{R_b\ [k\Omega]} = \frac{(V-3)^2\ [V]}{R_b \times 1000\ [\Omega]}\ [W] \text{ or more}$$

Simplifies to

$$P_b = \frac{V^2\ [V]}{R_b \times 1000\ [\Omega]}\ [W] \text{ or more}$$

* In actuality, select a wattage that is a few times greater than P_b.

Bleeder resistance that is necessary for the DC 2-wire type



⟨In the case that load current is under 3 mA when the output is in the ON state⟩

The bleeder resistance R_b and bleeder resistance power P_b can be calculated using the formula below.

$$R_b \leq \frac{\text{Supply voltage} - 3\ [V]}{3 - \text{Load current}\ [mA]}\ [k\Omega]$$

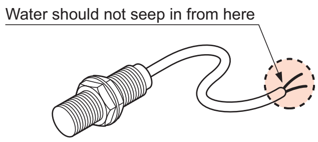
$$P_b > \frac{(\text{Supply voltage})^2\ [V]}{R_b \times 1000\ [\Omega]}\ [W]$$

* In actuality, select a wattage that is a few times greater than P_b.

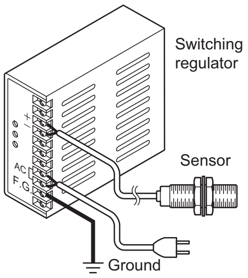
PRECAUTIONS FOR PROPER USE

Other precautions

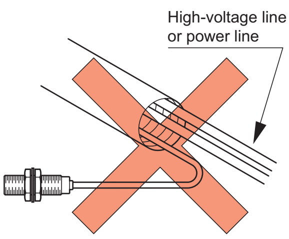
- Our products have been developed / produced for industrial use only.
- Although the protection degree is specified for the sensor including the cable, the cable end is not waterproof and is not covered by the protection specified. Hence, make sure that water does not seep in from the cable end.



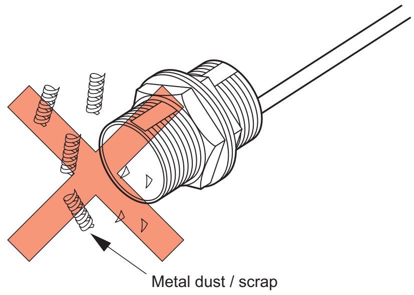
- Make sure that the power supply is off while wiring.
- Verify that the supply voltage variation is within the rating.
- If power is supplied from a commercial switching regulator, ensure that the frame ground (F.G.) terminal of the power supply is connected to an actual ground.



- If using electromagnetic valves, magnet switches, motors, etc. simultaneously in your system, control surges with a surge killer. Not doing so will cause chattering and other malfunctions.
- 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.

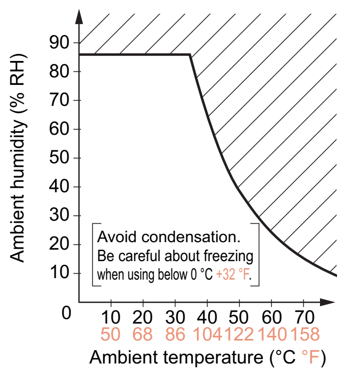


- Using wireless devices around sensors and wires may cause a malfunction. So make sure not to approach those.
- Take care that the sensor does not come in direct contact with organic solvents, such as, thinner, etc.
- Make sure that the sensing end is not covered with metal dust, scrap or spatter. It will result in malfunction.



(The spatter-resistant type **GX-F□U-J**, **GH-F8SE** prevents sticking of spatter due to its fluorine resin coating.)

- 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.
  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.



Photoelectric Sensors
Pressure Sensors
Flow Sensors
Inductive Proximity Sensors
Displacement Sensors
Electrostatic Sensors
Static Removers
About Laser Beam
General Precautions

MEMO