

PHOTOELECTRIC SENSOR GUIDE

Thank you for purchasing Autonics product.

Before use, be sure to read the safety considerations and use them correctly.

Autonics

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Selecting Photoelectric Sensors

It is an element to select a photoelectric sensor. Select the right product for each element for the most optimal detection.
You can check the details by referring to the contents.

① Sensing target

Check the material, size and color of the sensing target

Opaque materials, translucent materials, liquid level, PCB, color mark, etc.

② Sensing distance

Distance between photoelectric sensor and sensing target

15 m, 10 m, 7 m, 3 m, 1 m, 700 mm, 300 mm, 100 mm, etc.

③ Installation environment

Check environmental factors of the place where photoelectric sensor is installed, such as background

Glossy background, reflective background, dark background, bright background, environment with oil, etc.

④ Case material

Select the case material suitable for installation environment

Plastic, Ni-plate brass, SUS316L, etc.

⑤ Sensing type

Select the sensing type suitable for sensing target, sensing distance, installation environment, etc

Through-beam, retroreflective, diffuse reflective, BGS reflective, convergent reflective type, etc.

⑥ Power supply

Select the power supply of photoelectric sensor

AC, DC, free power, etc.

⑦ Control output

Select the control output of photoelectric sensor

NPN open collector, PNP open collector, NPN/PNP open collector simultaneous output, relay, etc.

⑧ Connection

Select the connection type of the photoelectric sensor

Cable type, connector type, cable connector type, etc.

What is a Photoelectric Sensor?

The photoelectric sensor is a device that detects an object using light. The difference in the amount of change between emitted light and received light determines the sensor's operation. With the non-contact method, the sensor can detect the presence/absence, passing, size, color, and contrast of an object. In order to select a suitable photoelectric sensor, it is important to know the characteristics (material, color, etc.) of the object to be detected and environmental conditions. The photoelectric sensors are classified in the categories below.

■ Through-beam type

Strength

- The longest sensing distance among the photoelectric sensors
- Resistance against contamination of the lens by dust or foreign substances

Lineup

- Through-beam type

■ Reflective type

Strength

- Easy or no adjustment is required for the optical axis
- Easy to arrange the wires and less installation space

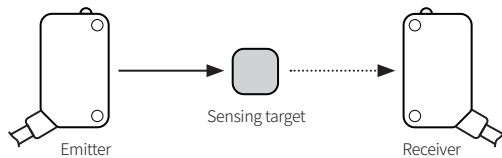
Lineup

- Retroreflective type
- Polarized retroreflective type
- Diffuse reflective type
- Narrow beam reflective type
- Convergent reflective type
- BGS reflective type

Sensing Types

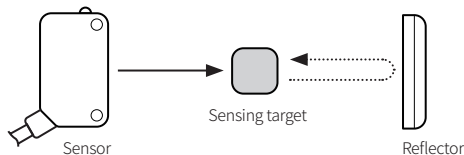
■ Through-beam type

It is a photoelectric sensor that occurs detection when an object passes between the emitter and receiver. It has the longest sensing distance among the sensing types of the photoelectric sensor.



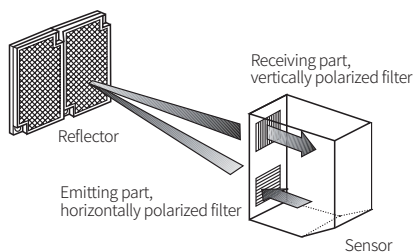
■ Retroreflective type

It is a photoelectric sensor that occurs detection when an object passes between the sensor and the reflector. The reflectivity of the object must be lower than that of the reflector for accurate detection. It has a longer sensing distance than the diffuse reflection type.



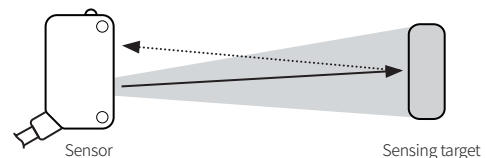
■ Polarized retroreflective type

It is a retroreflective photoelectric sensor with a horizontally polarized filter on the emitting part and a vertically polarized filter on the receiving part. The light-receiving element detects only the reflected light from the reflector which rotates the light by 90°. Therefore, an object passes between the sensor and the reflector, making the reflected light does not rotate, the light is blocked. Unlike the standard retroreflective type, it can detect glossy surfaces such as mirror, glass and transparent vinyl.



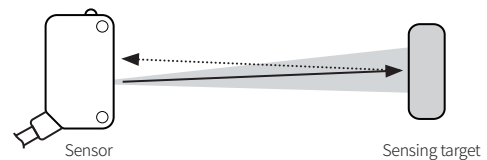
■ Diffuse reflective type

It is a photoelectric sensor that occurs detection when the reflected light from an object and returns to the light-receiving part. The sensing area is wide because the light is diffused after passing through the lens of the emitting part. The sensing distance may vary depending on the change in the intensity of received light due to the characteristics of the object (size, color, material, etc.).



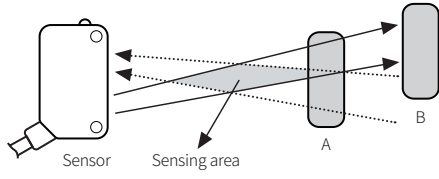
■ Narrow beam reflective type

It is a photoelectric sensor that has a narrowed beam size comparing to the diffuse reflection type. The sensing area is restricted, and the surrounding objects have little impact. It is suitable for detecting small objects or narrow spaces.



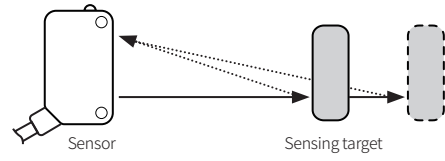
■ Convergent reflective type

It is a photoelectric sensor that detects an object in the area where the optical axes intersect. As this sensor detects an object only within a limited zone, the background and surrounding objects have little impact on its operation. However, it is not simple to modify sensing distance because the distance is adjusted by the angle of the optical system. It has a relatively short sensing distance.



■ BGS reflective type

It is a photoelectric sensor that detects an object at a specific distance when reflected light from an object enters the light-receiving element. The difference in angle of reflection occurs depending on the position of the object, and the light-receiving element sets the distance based on this. The characteristics of the sensing object (size, color, material, etc.), background, and surrounding objects have barely impact on this sensor and it has resistance to changes in temperature or power supply, therefore, it shows stable sensing performance.

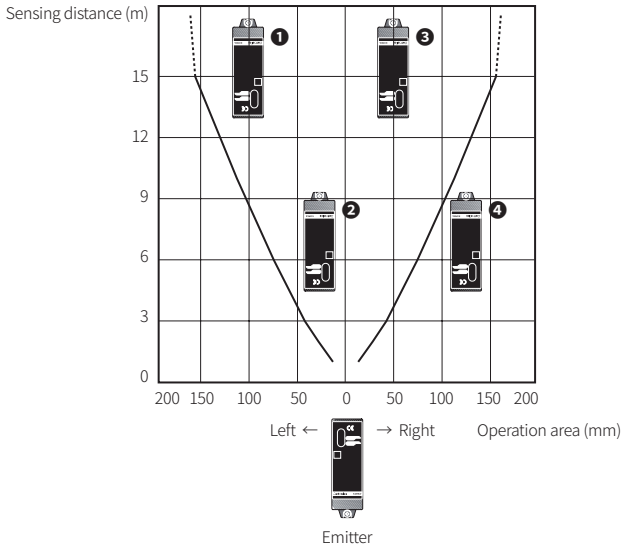


■ Through-beam type

• Sensing area

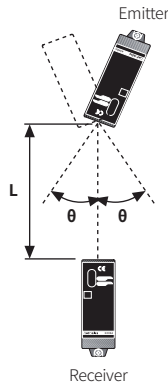
It shows the beam coverage of the emitter, meaning the range that the receiver operates normally as moving the emitter to the left/right from the sensing distance. You can refer to this data to prevent mutual interference when installing multiple sensors.

In the figure below, the receiver ①, ②, ③ operate normally while the receiver ④ does not operate since it is out of the beam coverage. For instance, the receiver is placed at 9 m of sensing distance, there must be 220 mm (twice of the operation area) of the interval between other sensors to prevent mutual interference.



• Emitter angle

It shows the installation angle of the emitter, meaning the operation range when the angle of the emitter is reduced with moving toward the center axis from the left/right direction of the sensing distance.



■ Retroreflective type

• Sensing area

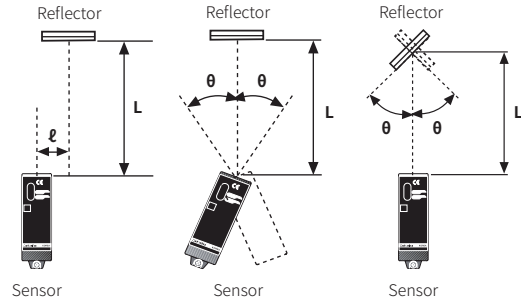
It shows the beam coverage of the emitted light. You can refer to this data to prevent mutual interference when installing multiple sensors and for a suitable installation range of the reflector.

• Sensor angle

It shows the installation angle of the sensor, meaning the operation range when the sensor is rotated to the left/right from the optical axis to the reflector.

• Reflector angle

It shows the installation angle of the reflector, meaning the operation range when the reflector is rotated to the left/right from the optical axis to the sensor.



■ Reflective type

• Sensing area

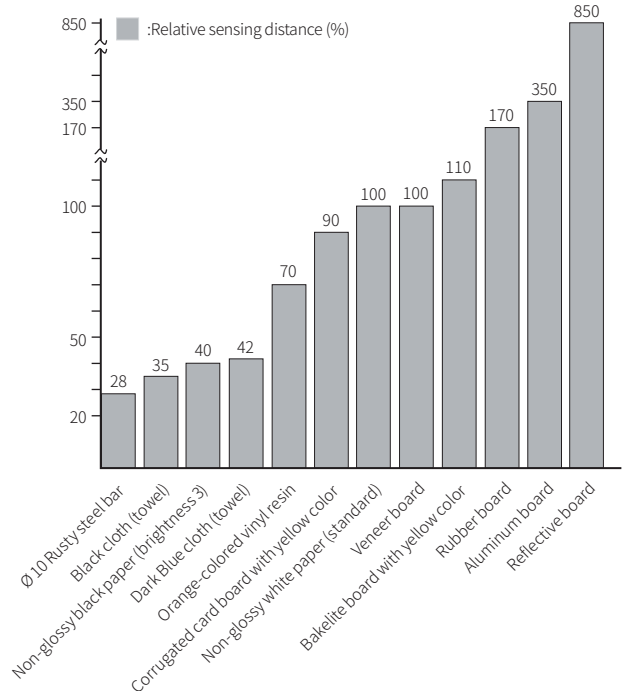
It shows the beam coverage of the emitted light. You can refer to this data to prevent mutual interference when installing multiple sensors and for the sensing range of the target. The principle of operation is the same as that of the retroreflective type.

• The size and reflectivity of the sensing target \propto Sensing distance

In case of the reflective type, the condition of the sensing target affects the sensing distance/sensing area. As the rate of reflection of the sensing target is lower, the sensing area is narrower. However, the non-glossy paper has a lower reflectivity than SUS or aluminum plate, but the sensing area is wider due to the diffused reflection of the surface.

• Relative sensing distance

It shows the ratio of sensing distance from each color of sensing targets based on the sensing distance of non-glossy white paper. The relative sensing distance may differ depending on the type of photoelectric sensor or the size of the sensing target. The convergent reflective type and the BGS reflective type can be used in an alternative way because they are barely affected by color.



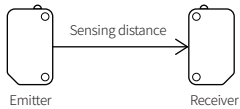
■ Sensing target

It is an object that the photoelectric sensor detects.

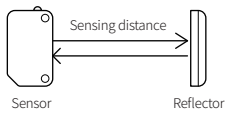
- Standard sensing target: It is a standard sensing object to determine the specifications of the sensor (reflective type). The non-glossy white paper is commonly used.
- Min. sensing target: It is the smallest object that the sensor can detect. It is expressed as opaque materials, translucent materials, outer diameter (Ø, unit: mm) of copper wire, etc.
- Min. sensing target with slit: Through-beam type with the slit (sold separately) can narrow the beam coverage, preventing mutual interference caused by multiple sensors and detecting smaller objects. However, since the sensing distance is getting shortened, be sure to check the min. sensing target and sensing distance depending on the specifications of the slit.

■ Sensing distance

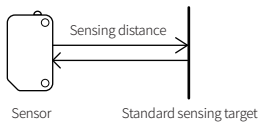
- Through-beam type
: It is a distance that the emitter and the receiver can be installed in stable operations.



- Retroreflective type
: It is a distance that the sensor and the reflector can be installed in stable operations.

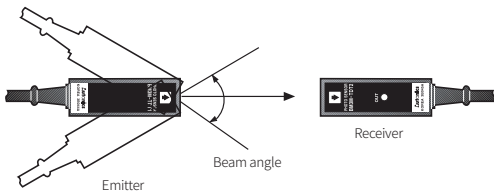


- Reflective type
: It is a distance that the standard sensing target (e.g., non-glossy white paper) can be detected in stable operations.



■ Beam angle

It is the range of angle that the photoelectric sensor shows stable sensing performance.



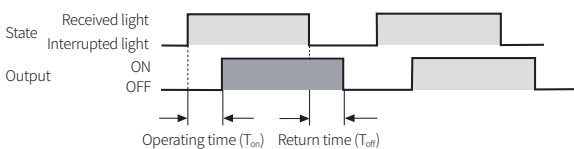
■ Response time

It is the time range between the state of light is changed, and output becomes ON or OFF.

Generally, response time is expressed as operating time (T_{on}).

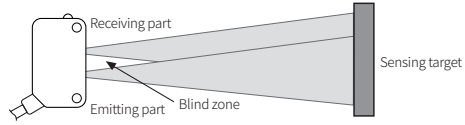
Operating time (T_{on}) \approx Return time (T_{off})

- Light ON mode



■ Blind zone

The blind zone is formed near the receiving and the emitting part of the reflective sensor type. Since no object or target is detected within this area, be cautious when installing the sensor.



■ Operation mode

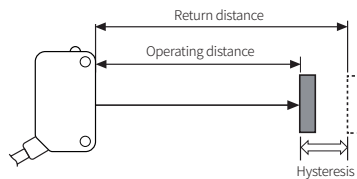
- Light ON (operation when the light is received)
: The output becomes ON when the received part detects emitted light.
- Dark ON (operation when the light is interrupted)
: The output becomes ON when the received part does not detect emitted light.

	Through-beam	Retroreflective	Reflective
Received			
Interrupted			

■ Hysteresis

It is the difference between the operating distance and the return distance of the reflective sensor. It is expressed as a ratio (%) to the sensing distance.

- Operating distance: It is the distance that the sensor firstly operates as Light ON mode.
- Return distance: It is the distance that the sensor does not operate as Light ON mode when the standard sensing target is moving away, the position where the output is reset.



■ Ambient illuminance

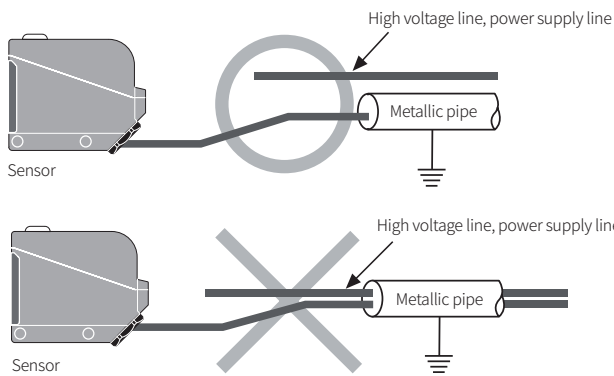
It means the illuminance that the sensor operates in a normal and stable way. It indicates the illuminance of the light-receiving surface and is generally expressed as sunlight and incandescent lamps.

■ Cautions during installation

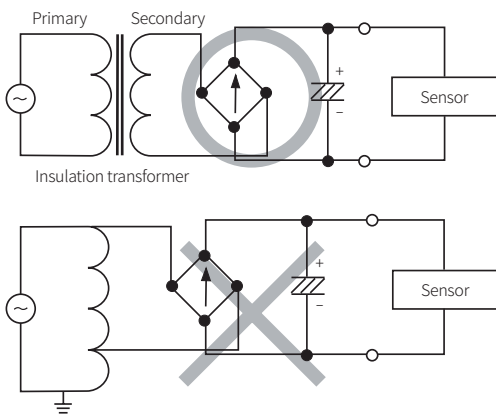
- Select a photoelectric sensor with a suitable sensing distance concerning the installation environment. If the sensing distance is too long or short, it may cause a malfunction of the sensor.
- Select a photoelectric sensor with a smaller diameter than that of the sensing target.
- If there is a possibility that the sensor to be damaged by sensing targets or objects, be sure to use protective covers for protecting the photoelectric sensor.
- In case the sensor is applied to high-frequency machines, such as ultrasonic welding machine, etc, it may cause a malfunction due to the induced current. Be sure to insulate between the sensor and high-frequency machines using insulating boards.
- Install the cable as short as possible. In case of cable extension, make sure that the thickness of the cable should be over 0.3 mm² and be cautious of the voltage drop.
- Take the following measures for the photoelectric sensor to prevent exposure to strong vibration or shock.
 - ① Do not make the sensor's main body collide with the sensing target directly.
 - ② Use a support bracket made of sturdy materials to prevent vibration or shock.
 - ③ Tighten bolts and nuts of fixing brackets with the indicated torque.

■ Cautions for operating power and grounding

- In case of commercial power, use a power supply with low noise/voltage variations. Avoid using the sensor around the power generators or high voltage lines.
- If the case material of the photoelectric sensor is made of metal, ground the case to prevent product malfunction caused by static electricity and noise.



- In case of DC power photoelectric sensors, use insulation transformer for rectified power supply with $\pm 10\%$ ripple.



■ Cautions for power supply

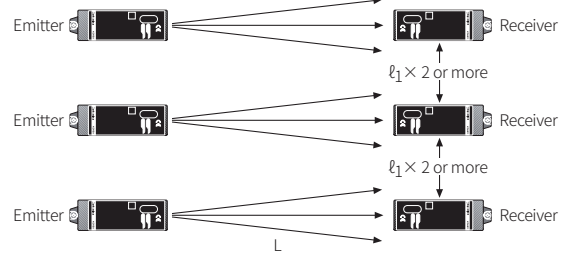
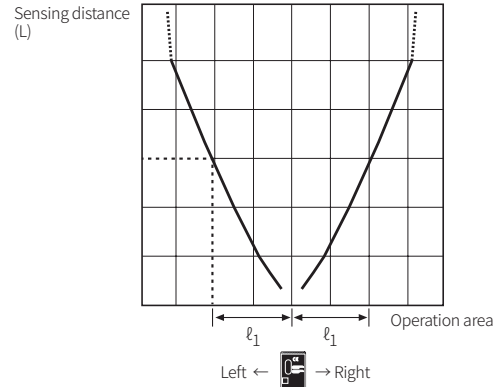
- Do not operate the output of the sensors by power ON/OFF.
- The photoelectric sensor requires at least 500 ms for stable operation after power is ON.

■ Countermeasures for mutual interference

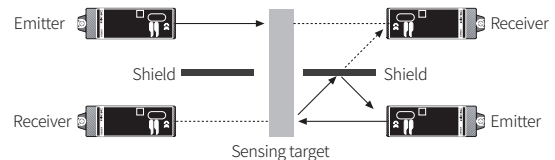
When installing multiple photoelectric sensors closely, follow the measures below to prevent mutual interference that may affect operations.

• Through-beam type

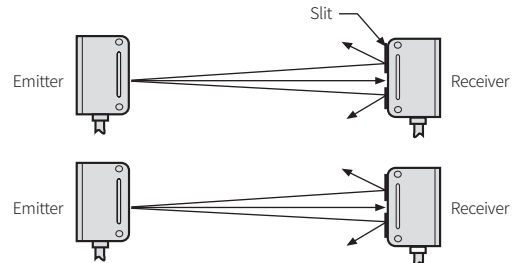
01. Check the sensing area in the feature data. Figure out a value of the operation area for the sensing distance L , and install the sensor with an interval of twice or more than the value.



02. Place the emitter and the receiver alternately. If the space of sensors is too close, it may cause malfunction due to the reflected light. Install the shield between the sensors to block the light.



03. Narrow the light by using the slits on the receiver.



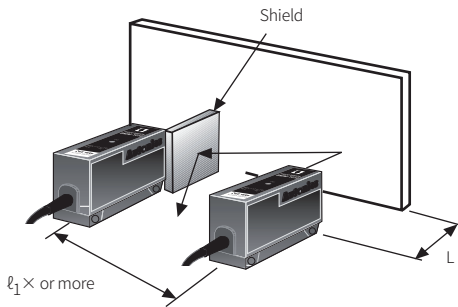
Installation

■ Countermeasures for mutual interference

• Reflective type

01. Check the sensing area in the feature data. Figure out a value of the operation area for the sensing distance L , and install the sensor with an interval of twice or more than the value.

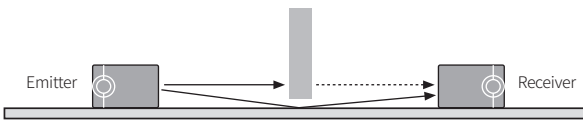
02. Install a shield between the sensors.



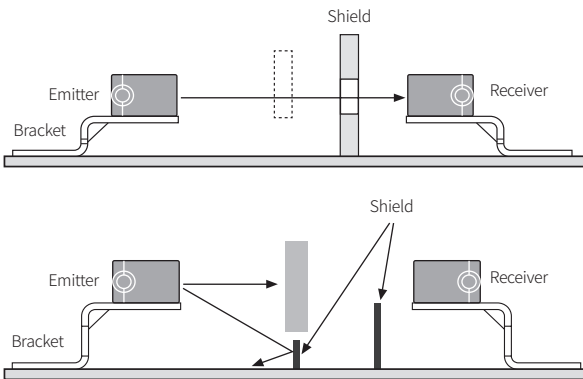
■ Countermeasures for influence of surrounding object

• Through-beam type

When installing the photoelectric sensors in close contact with the mounting surface, the light-received state can be maintained due to reflected light, even if a sensing target is passing through the sensing area.

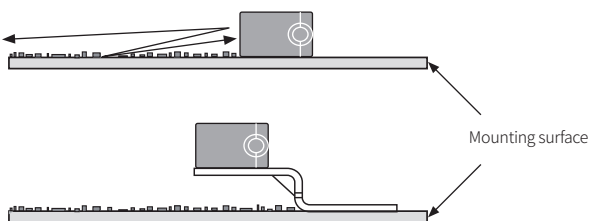


01. Install the sensors using a shield or bracket in the figure below.



• Reflective type

01. The effect of mounting surface: A rough mounting surface can cause the malfunction of the photoelectric sensor due to the diffusely reflected light. Install the sensor high using a bracket.

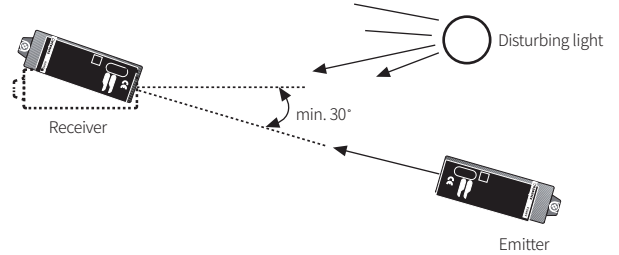


02. The effect of background object: Even if the background object is apart from the sensing target, it may affect sensing performance, since the background or wall behind the sensing target is often large. Paint the background object in black color to reduce reflected light. Increase the distance from the background. Or select a convergent reflective type sensor.

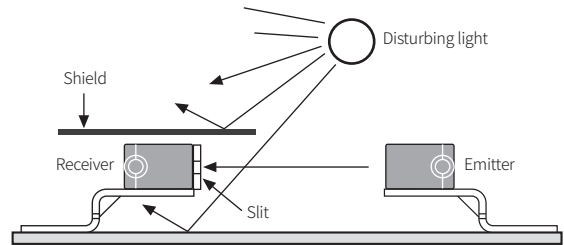
■ Countermeasures for disturbing light

Strong disturbing light (direct rays of sunlight) or modulated disturbing light (arc welding spark, inverter fluorescent) may cause malfunction of the photoelectric sensor.

01. Install the optical axis of the receiver with more than 30° for the angle of incidence from disturbing light.



02. Use a slit on the receiver or shield to block the disturbing light.



APPENDIX

Safety Certification for Product and Component	III
Communication Standards	V
IP Code (protection against dust and water)	VI

Safety Certification for Product and Component

- For detailed certification information, visit the website of each certification body.
- For the status of certification on our product, visit the Autonics website.

■ CE

- Country: European Union



CE marking is the conformity marking, meaning that it complies with all Directives of the Council of European Union regarding safety, health, environmental, and consumer protection standards.

If a product judged to be a risk to the consumer's health, safety, and environmental protection, is sold in the European market, the CE mark must be affixed. It is an essential certification for entry into the European market.

■ UL Listed

- Country: United States



UL listing is the American standard for safety. It is a non-mandatory standard, but most States mandate this standard. This certification is highly favored by consumers.

UL Listed Mark means the end product meets standards of safety.

■ TR CU

- Country: Eurasian Economic Union



The EAC certification is accredited by five member countries of the Eurasian Economic Union (EAEU): Russia, Kazakhstan, Belarus, Armenia, and Kyrgyzstan.

Regulated products without the EAC mark are prohibited to access the markets of 5 members of EAEU.

- Type of certification
 - : Certificate of Conformity (CoC),
 - Declaration of Conformity (DoC)

■ KC

- Country: Republic of Korea



The KC certification mark must be affixed on an imported or domestically manufactured electrical product that is to be distributed or sold in Korea.

Type of certification: safety certification, EMC certification

- Safety certification: Korean Agency for Technology and Standards (KATS) affixes and manages the KC certification mark for electrical appliances, household goods, and children's products by dividing the steps into safety certification / safety confirmation / supplier's declaration of conformity (SODC) according to the different levels of potential danger.
- EMC certification: Manufacture, sale, or import for equipment that may cause harm to the radio environment and broadcasting communication network, or that may cause or receive significant electromagnetic interference, the KC certification mark is issued through electromagnetic compatibility (EMC) testing.

■ S-Mark

- Country: Republic of Korea



The S-Mark is the optional certification system to prevent industrial accidents. Korea Occupational Safety and Health Agency (KOSHA) conducts a comprehensive evaluation for the safety and reliability of product, and the capability of quality control in manufacturing.

Due to non-mandatory, there is no regulation or disadvantage on the uncertified product.

■ UKCA

- Country: United Kingdom



UK Conformity Assessed (UKCA) is a certification mark that indicates conformity with the applicable requirements for products sold within Great Britain (England, Scotland and Wales).

UK certification authorities can not issue EU legal certificates and existing UK certificates are no longer recognized on the EU market. Manufacturers who have previously used legally required certificates from UK authorities must transfer them to institutions within the EU or apply to new institutions.

For products to be released in the EU market, CE certification marks are required as before.

■ UL Recognized

- Country: United States



UL listing is the American standard for safety. It is a non-mandatory standard, but most States mandate this standard. This certification is highly favored by consumers.

UL Recognized Mark means the components intended for use in a complete product or system meet standards of safety.

■ KCs

- Country: Republic of Korea



The Minister of Employment and Labor evaluates the safety of hazardous or dangerous machinery, equipment, facilities, protective devices, and protective equipment based on the 'safety certification standards.' Occupational Safety and Health Agency (Ulsan, in South Korea) certifies safety through comprehensive tests complying with the 'safety certification standards.'

Any person who intends to manufacture, import, or change major structural parts of products subject to safety certification, must obtain this certification.

■ TUV NORD

- Country: Germany



TUV is a leading German private certification body that has been responsible for many testing and certification tasks related to safety in the industry for a long time. It is intended to protect people and property from fire and other accidents. Currently, TUV is conducting tests and inspections on safety and quality in various industries such as machinery, electronics and electricity, automobiles, chemical facilities, nuclear power, and aircraft. It is voluntary standards, and certification is issued complying with various EU Directives and German safety regulations.

■ Metrology Certification

- Country: Russia



Metrology Certification is a certificate for measuring and test equipment. Registration of measuring equipment is currently being revised and implemented following the Russian Federal Law, and is managed and supervised by the measurement authority, which is the subject of the certification. Measurement authorities review and test measuring equipment to be used in the Russian Federation based on the State System of Measurement (SSM), issue certificates, and manage them in the government's online database for users and buyers to browse.

■ CCC

- Country: China



The China Compulsory Certificate system (CCC) is a compulsory mark for products that met Chinese technical standards and are allowed to be imported by the Chinese government. Foreign-imported industrial products are examined through CCC certification process whether they meet safety standards or not. The certified products are distributed and sold with the CCC mark or factory code according to the product. CCC certification is administered by the China Quality Certification Center (CQC).

■ PSE

- Country: Japan



PSE is a compulsory certification administered by the Ministry of Economy, Trade and Industry (METI) and governs by the Electrical Appliances Safety Law in Japan. The purpose is to minimize the occurrence of harm and damage caused by electrical equipment by regulating the manufacture and sale of electrical appliances and bring an engagement of the private sector to ensure the safety of electrical appliances. Manufacture, import, and sell electrical appliances in the Japanese market, the technical standards for those products must be satisfied and the PSE certification mark must be displayed.

■ GOST

- Country: Russia



GOST is national technical standards set by the Euro Asian Council for Standardization, Metrology and Certification (EASC). The abbreviation GOST stands for GOsudarstvennyy STandart, which means State Union Standard in Russian. The current GOST standard includes over 20,000 titles and is widely used in common in the Commonwealth of Independent States (CIS) (12 countries). All countries of the CIS currently adopt and use the GOST standard, but the certificates issued by each country and the subject of the issuing certification body are different, so each country's GOST certificate can be regarded as a different certificate. The national standards of Russia are the GOST R, those of Kazakhstan are GOST K, etc.

■ China RoHS

- Country: China



China RoHS is the Chinese government regulation to control and eliminate the environmental impact of toxic and hazardous substances and elements in electrical/ electronic equipment. China's Measures for the Administration of the Control of Pollution by Electronic Information Products like the EU RoHS Directive have been enacted, and regulate additional hazardous substances compare to EU RoHS. Marking a logo or label for marking information is mandatory. In addition, there is a certification system before selling the product to ensure its conformity by conducting test analysis. Products to be exported to China will be screened prior to customs entry. Customs entry is only permitted for products that meet conformance standards.

Communication Standards

• For detailed information on communication, visit the related association's website.

■ EtherNet/IP

EtherNet/IP™

EtherNet/IP is an industrial network protocol that conforms Common Industrial Protocol to standard Internet. It is one of the leading industrial protocols in the United States and is widely used in a variety of industries, including factories.

EtherNet/IP and CIP technologies are managed by ODVA, Inc., a global trade and standards development organization founded in 1995 with over 300 corporate members.

EtherNet/IP uses the most widely adopted Ethernet standards - Internet Protocol and IEEE 802.3 - to define functions for the transport, network, data link, and physical layer. CIP uses object-oriented design to provide EtherNet/IP with services and device profiles needed for real-time control and to promote consistent implementation of automation functions across a diverse ecosystem of products.

■ DeviceNet

DeviceNet

DeviceNet is a digital multidrop network to interconnect industrial controllers and I/O devices. DeviceNet provides users a cost-effective network for distribution at no cost, deploys and manages simple devices across the architecture.

DeviceNet uses CAN (Controller Area Network), a network technology used in automobile vehicles, for its data link layer, and this network is used in almost all industries. DeviceNet is approved by CENELEC for its official standard and is also used as a global standard.

■ ProfiNet



PROFINET, designated and announced by PI (PROFIBUS & PROFINET), is the open standard for industrial Ethernet in automation technology. It provides solutions for process automation, factory automation and motion control. It enables the integration of existing fieldbus systems such as PROFIBUS, Interbus and DeviceNet into an open Ethernet-based network. PROFINET, the protocol for communication, configuration and diagnosis in the network, uses Ethernet standard as well as TCP, UDP, IP. It achieves fast and safe data exchange, enabling the concepts of innovative machine and plant. Thanks to its flexibility and openness, PROFINET offers the users a freedom in building machine and plant architectures and significantly increases plant availability by optimal use of resources available to users.

■ CC-Link



CC-Link is the open field network and the global standard with SEMI certification. As high-speed field network, CC-Link can process both control data and information data at the same time. With a high communication speed of 10 Mbps, it supports a transmission distance of 100 meters and connects to 64 stations.

It achieved high-speed response of up to 10 Mbps, guaranteeing punctuality. With CC-Link, complex production lines can be simplified and built at low cost. There are advantages of reducing the cost of wiring components, shortening the wiring construction period, and improving maintainability.

CLPA provides a memory map profile that allocates data for each product type. CC-Link compatible products can be developed based on this profile, and users can use the same program for connection and control even if existing product is replaced to other vendors' one.

■ EtherCAT



EtherCAT (Ethernet for Control Automation Technology) is an Ethernet-based fieldbus system developed by Beckhoff Automation. After releasing the technology from ETG (EtherCAT Technology Group) in 2003, it is standardized in IEC 61158 since 2007. It is a communication method that uses the frame according to IEEE 802.3 and physical layer and is an Ethernet protocol-based automation software that requires low jitter, short cycle time, and reduced hardware cost.

EtherCAT supports almost all topologies which have the advantage of flexibility and user-friendly. Due to the high-speed network, EtherCAT is suitable for applications requiring simultaneous operation.

■ HART



HART is the global standard for digital information communication via analog wires between smart devices and control or monitoring systems.

It is the duplex communication protocol and supports various analog I/O modules with HART connection. It sends and receives digital information through 4-20 mA current. It provides a reliable and long-term solution for plant operators who seek the benefits of smart devices with digital communication while maintaining existing facilities for analog instrumentation and plant wiring. Many sites that have applied the HART protocol can access to many digital process, maintenance and diagnostic information.

■ ProfiBus



ProfiBus is the open standard commonly used for process automation in the production site.

- Configuration
 - Master: It determines data traffic, transmits messages, and performs as role of Active Station.
 - Slave: It means I/O devices, valves, motor drivers, transmitters, etc. Slave receives a message and transmits the message depending on the Master's request.
- Up to 124 slaves and 3 masters can be connected to one communication line, and the communication method uses the half duplex method. Each device is connected to the bus in parallel and each device has its network address, so the installation location is irrelevant. Each device can be moved or removed during the communication.

IP Code (protection against dust and water)

IEC (International Electro-technical Commission) Standard

The IP Codes are defined in the IEC standard 60529.



1 Degree of protection against dust (protected from solid foreign objects)

Numeral	Degree of protection	Degree of protection
0	Non-protected	
1		Protection against the objects with 50 mm diameter or more The object probe, sphere of 50 mm diameter, must not fully penetrate. - Test means : Rigid sphere without handle or guard. - Test force: 50 N ± 10%
2		Protection against the objects with 12.5 mm diameter or more. The object probe, sphere of 12.5 mm diameter, must not fully penetrate. - Test means : Rigid sphere without handle or guard. - Test force: 30 N ± 10%
3		Protection against the objects with 2.5 mm diameter or more. The object probe, sphere of 2.5 mm diameter, must not fully penetrate. - Test means : Rigid steel rod with edges free from burrs. - Test force: 3 N ± 10%
4		Protection against the objects with 1 mm diameter or more. The object probe, sphere of 1 mm diameter, must not fully penetrate. - Test means : Rigid steel rod with edges free from burrs. - Test force: 1 N ± 10%
5		Protection against the dust with or without pressure. - Dust-protected enclosures allow a limited quantity of dust to penetrate; complete protection against contact. Test duration: 8 hours Dust (the talcum powder) : It must be able to pass a square-meshed sieve that its nominal wire with 50 µm diameter; the nominal width of a gap between wires 75 µm. The amount of talcum powder: 2 kg/m ³
6		Protection against the dust under pressure. - Dust-tight enclosures do not allow any dust to penetrate. Test duration : 2 hours (a volume of dust: 40 to 60 / hour) 8 hours (a volume of dust: less than 40 / hour Depression : Less than 2 kPa (20 mbar) on the manometer. Dust (the talcum powder) : It must be able to pass a square-meshed sieve that its nominal wire with 50 µm diameter; the nominal width of a gap between wires 75 µm. The amount of talcum powder: 2 kg/m ³

2 Degree of protection against ingress of water (protected from liquids)

Numeral	Degree of protection	Degree of protection
0	Non-protected	
1		Protection against vertically falling water drops. Water drops flow over the whole area of four sides on a fixed and tilting enclosure. - Test duration : 10 min (2.5 min in each of four sides)
2		Protection against vertically falling water drops when the enclosure is tilted up to 15° from its normal position. Uniform flow of water drops over the whole area of the enclosure. - A rotation speed of turntable: 1r / min - Test duration: 10 min
3		Protection against spraying water at an angle up to 60° on either side of the vertical. The oscillating tube has spray holes over an arc of 60° either side of the center point. It sprinkles through an angle of 120° and 60° on either side of vertical. Then, the enclosure is turned through a horizontal angle of 90°, and continue the test for 5 min. - Test duration : 10 min (5 min in each of sides) - Mean flow rate per hole: 0.07 L/min
4		Protection against splashing water from any direction. - No harmful effects on the product. The oscillating semicircle tube with spray holes sprinkles through an angle of 360°. - Test duration: 10 min - Mean flow rate per hole: 0.07 L/min
5 ⁽⁰¹⁾		Protection against projecting water in jets from any direction. - No harmful effects on the product. Spraying a stream of water from the test nozzle (internal diameter: Ø 6.3 mm) at all directions. - Test duration: 3 min - Distance from nozzle to enclosure surface : 2.5 to 3 m - Delivery rate: 12.5 L/min ± 5%
6 ⁽⁰¹⁾		Protection against powerfully projecting water in jets from any direction. - No harmful effects on the product. Spraying a stream of water from the test nozzle (internal diameter: Ø 12.5 mm) at all directions. - Test duration: 3 min - Distance from nozzle to enclosure surface : 2.5 to 3 m - Delivery rate: 100 L/min ± 5%
7 ⁽⁰²⁾		Protection against temporary immersion in water under defined conditions of pressure and time. - The product is hermetically sealed. Immersion in water under defined conditions - Test duration: 30 min - Water level: 1 m
8 ⁽⁰²⁾		Complete protection against continuous immersion in water. - The product is hermetically sealed. - Conditions negotiated between the manufacturer and the user - Strict conditions than IPX7

01) The degree of protection against spraying does not guarantee the effects of immersion.

02) The degree of protection against immersion does not guarantee the effects of spray.

■ DIN (Deutsche Industrie Normen) Standard

The DIN standard is defined in the DIN 40050-9.

IP 1 2

1 Degree of protection against dust (protected from solid foreign objects)

Same as IEC standard

2 Degree of protection against ingress of water (under high temperature and high pressure)

Letters	Degree of protection	
9K	Water resistance under high temperature and high pressure	Protection against high-temperature vapor and high-pressure water at all directions. - No harmful effects on the product.

■ JEM (Japan Electrical Manufacturers' Association) Standard

The JEM standard is defined in the JEM 1030.

IP 1 2 3

1 Degree of protection against dust (protected from solid foreign objects)

Same as IEC standard

2 Degree of protection against ingress of water (protected from liquids)

Same as IEC standard

3 Degree of oil proof / oil resistance

Letters	Degree of protection	
F	Oil proof type	Protection against oil drop and oil powder in all directions - Even if oil penetrates in the product, it operates normally.
G	Oil resistant type	Protection against oil drop and oil powder in all directions - Special coating prevents penetration of oil into the product.

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Dimensions or specifications on this manual are subject to change and some models may be discontinued without notice.