Order No: *****

First Edition

Revision level: 08/2023

By Cardinal Automation, LLC

Internet: www.cardinalautomation.co

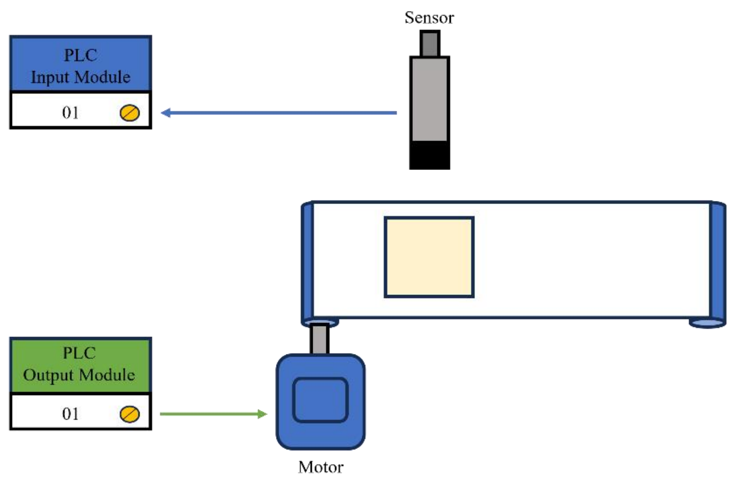
e-mail: contact@cardinalautomation.co

Printed in United States

Table of Contents

Understanding Industrial Sensors

Industrial sensors play a crucial role in indicating the status of devices or processes within a PLC program. By understanding these input states, the PLC program can make informed decisions, such as initiating or stopping a conveyor motor.



The diagram showcases a Programmable Logic Controller (PLC) running a ladder logic program, with an inductive proximity switch linked to a PLC input card. The logic program is designed to sense the state of the switch.

For instance, in the scenario where a box is placed on a conveyor at the loading point, the proximity switch detects the box's presence. Upon sensing the nearby object, the circuit closes, and the PLC registers the input state as ON (1) and commands the conveyor motor to start, moving the box to the next inspection station. When the sensor doesn't detect an object nearby, the PLC sees the input state as OFF (0), with the circuit to/from the PLC input open and unenergized.

To integrate a sensor input into the PLC program, one needs to comprehend industrial sensors and their connection to the PLC.

Industries across the globe are being compelled to embrace automation in the face of intense global competition. To effectively compete, automation needs to exhibit both speed and flexibility. To achieve this, the integration of programmable control devices, including PLCs and programmable automation controllers, with industrial sensors is pivotal. This integration yields the creation of intelligent and adaptable systems.

With the surge in automatic operations, ensuring operator safety becomes paramount. A range of safety devices has been developed to address this concern. For instance, laser scanners are employed to prevent unauthorized entry into restricted areas, while special interlocks are implemented to guarantee that safety doors remain locked during operation within these areas.

Moreover, sensors offer additional functionalities such as verifying the presence or absence of parts, measuring sizes, ensuring proper fill levels, and more. The role of industrial sensors extends beyond mere safety applications. These sensors play a central role in detecting and signaling alterations in specific conditions. These changes could encompass various aspects, from the binary determination of an object's presence or absence (known as discrete sensing) to the measurement of quantifiable attributes like changes in distance, dimensions, or color (analog sensing). The data provided by these sensors, known as the sensor's output, serves as the foundation for supervising and controlling various manufacturing processes.

Contact and Noncontact Sensor Types

In industrial contexts, two primary sensor types, contact and noncontact sensors, each serve distinct purposes.

Contact Sensors: These sensors, known as contact sensors, are electromechanical devices crafted to detect changes through direct physical contact with the target object. Notable characteristics of these sensors include:

- Operating typically without requiring external power sources.
- Being capable of handling higher currents and enduring disruptions in power lines.
- Being user-friendly, thus facilitating easy comprehension and troubleshooting.

Encoders, limit switches, and safety switches are examples of contact sensors. Encoders translate machine motion into signals, while limit switches find suitability in situations where direct physical contact can be established. Safety switches possess tamper-resistant actuation and immediate-opening action contacts, rendering them effective as machine guards and emergency stop mechanisms.

Noncontact Sensors: In contrast, noncontact sensors are solid-state electronic devices that establish an energy field or beam and respond to disturbances within that field. Key features associated with noncontact sensors include:

- Elimination of the necessity for direct physical contact with the target object.
- Absence of moving parts, which leads to reduced maintenance requirements.
- Capability to operate at higher speeds.
- Enhanced flexibility in application.

The domain of noncontact technologies encompasses photoelectric, inductive, capacitive, and ultrasonic sensors. The lack of physical contact effectively addresses concerns related to wear and tear. However, occasional interactions with the target material may still occur. It's also important to note that noncontact sensors can exhibit sensitivity to energy emitted by other devices or ongoing processes.

Discrete and Analog Sensing

There are two main categories for industrial sensors: discrete sensing and analog sensing, each defined by its functionality.

Discrete Sensing: Discrete sensing pertains to the fundamental question of "Is the target present?" When the sensor detects the presence or absence of the target, it generates an output signal usually in the form of a digital On/Off indication.

Analog Sensing: In contrast, analog sensing addresses more intricate queries like "Where is the target?" or "To what extent does it exist?" This is achieved through providing a continuous output response. The value of the output corresponds to the impact of the target on the sensor. This impact could be in terms of its position within the sensing range or the relative strength of the signal it reflects back to the sensor.

Understanding Sensor Characteristics

In the process of selecting the right sensor, it's vital to comprehensively evaluate key characteristics that define its performance.

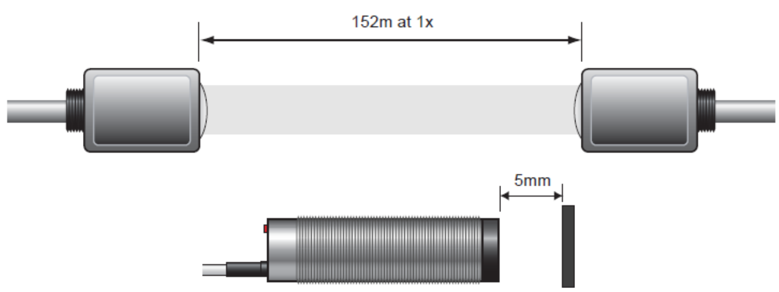
Nominal and Effective Sensing Distance

The sensing range is predominantly influenced by the size of both the coil and the sensor. This implies that a larger sensor diameter results in a correspondingly larger sensing range.

Additionally, the sensing range can be impacted by both the target and the target material. In the case of inductive sensors, the material of the target also plays a role in determining the sensing range. Ferrous metals are detected most effectively. Conversely, non-ferrous metals like aluminum are not as effectively sensed, often requiring a reduced sensing range.

When selecting sensors, a crucial consideration revolves around both the nominal and effective sensing distances, which need to be tailored to the specific requirements of the application.

Nominal Sensing Distance: This distance signifies the predetermined operational range for which a sensor is designed. This rating is established under standardized conditions and serves as a benchmark for typical performance.

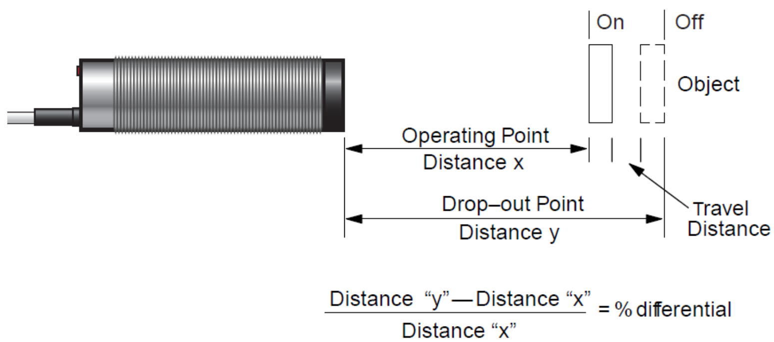


Effective Sensing Distance: In the practical context of an installed application, the effective sensing distance becomes significant. It represents the actual sensing distance achieved by the sensor. This distance lies between the ideal nominal sensing distance and the less favorable worst-case sensing distance.

Hysteresis and Consistency

Hysteresis, also known as differential travel, is another crucial consideration. It encompasses the variation between a sensor's operating point (switch on) and release point (switch off) as the target moves away from the sensor's surface. This disparity is expressed as a percentage of the sensing distance. Maintaining appropriate hysteresis is vital to prevent disruptive behavior like the occurrence of continuous switching on and off, commonly termed as "chatter." This becomes particularly relevant in scenarios where the sensor or target experiences significant vibrations.

Hysteresis, in the context of sensors, involves the presence of distinct on and off points. The sensor output remains inactive until the target surpasses the on point, at which stage it becomes active and stays so until the target moves away and crosses the off point.



It's important to note the distinction between these turn on and turn off points.

To illustrate this concept, envision an object moving horizontally within the sensor's sensing range. Initially, the object enters the field at the turn off point, and the output remains unchanged. As the object progresses, it eventually reaches the turn on point, triggering a change in the output state. Assuming the output is now active, the object continues its motion. The trailing edge of the object eventually exits the turn on point on the opposite side of the sensor. During this period, the output state remains constant. It's only when the trailing edge exits the turn off point that the output switches back to the off state.

Hysteresis delivers a significant advantage in sensing. It prevents the sensor from being triggered multiple times by the same object. For instance, consider a bottle moving along a conveyor line. Without hysteresis, the bottle's vibrations could cause it to be sensed multiple times as it passes the sensor. Hysteresis ensures that such cases are counted only once.

Reliable Repeatability

The repeatability of a sensor refers to its ability to consistently detect the same object at a fixed distance.

This measurement is quantified as a percentage in relation to the nominal sensing distance.

To assess repeatability accurately, the evaluation is conducted under conditions of consistent ambient temperature and supply voltage.

Switching Frequency and Response Time

When selecting a sensor, it's important to consider its ability to sense and switch the output with the necessary speed to meet the demands of the application. For most applications, this is unlikely to be an issue as electronic sensors are inherently fast, especially in high-speed scenarios. Nonetheless, it's essential to factor in the sensor's switching time, accounting for both the time the target remains within range and the time between successive targets.

An aspect deserving attention is the response time, which denotes the time elapsed between the target being detected and the change in the output state. This response time becomes particularly critical in high-production environments. Manufacturers provide response times in sensor specification sheets.

Two additional factors warrant careful consideration: switching frequency and response time.

Switching Frequency: This signifies the number of switching operations performed per second under standardized conditions. Essentially, it reflects how swiftly the sensor can operate.

Response Time: The response time of a sensor characterizes the duration between the target being detected and the alteration of the output state, which can involve transitioning between ON and OFF or OFF and ON. This timeframe also encompasses the duration it takes for the output to change state once the target is no longer within the sensor's range.

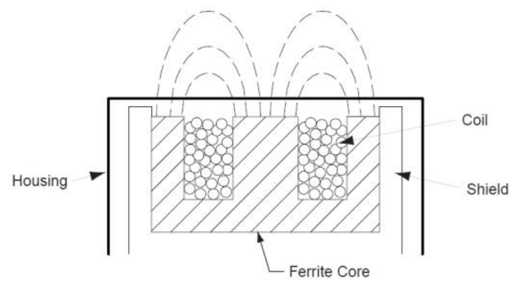
Choosing an appropriate response time hinges on the size of the target and its velocity as it moves past the sensor.

Shielded vs. Unshielded Construction

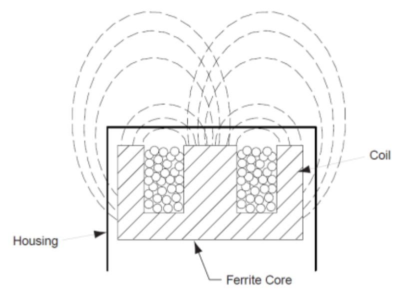
A standard field sensor generates a field that doesn't just extend from the end of the sensor; it also emanates from the sides of its center. As a consequence, it becomes capable of sensing objects positioned on the sides of the sensor. While this capability might seem advantageous, it often leads to undesired outcomes, such as sensing the fixture it's mounted in.

To counter this issue, sensors come in two styles: shielded and non-shielded. Shielded sensors are sometimes referred to as flush sensors because they are designed for flush mounting, meaning they are installed so that the sensor face aligns with the mounting surface. In contrast, non-shielded sensors are also known as non-flush sensors. A shielded sensor features a brass or copper ring encircling the coil, preventing the generated field from extending to the sides. This reduces the sensing range but allows for flush mounting.

Shielded Construction: Shielded sensors incorporate a shielding ring or metal housing that concentrates the electromagnetic field towards the sensor face. This design facilitates flush mounting even in metal environments, ensuring accurate sensing without false triggers.



Unshielded Construction: Unshielded sensors lack metal bands around their core/coil assembly, leading to a less focused electromagnetic field. These sensors have a substantially larger sensing range, making them sensitive to surrounding metals. However, they cannot be flush-mounted in metal surfaces without causing false triggers and require proper spacing to prevent overlap.



By understanding the differences between shielded and unshielded constructions, you can make informed decisions regarding the sensor and their application in various scenarios.

Determining Power Sources for Sensors

When selecting sensors for your application, it's essential to begin by identifying the available power source, which can be either AC or DC.

Voltage Ranges and Compatibility Sensors are designed to align with different voltage ranges commonly encountered in the field. These typically fall into four categories:

- **10-30V DC**
- **20-130V AC**
- **90-250V AC**
- **20-250V AC/DC**

AC sensors and switches have the capability to draw power directly from the power line or a filtered source, eliminating the necessity for a separate power supply. This connection method is generally perceived as more robust and rugged.

AC and DC Considerations

On the other hand, DC sensors require a separate supply to isolate the DC portion from the AC signal. Despite this requirement for separation, DC voltages are generally considered safer than AC. DC sensors are available in both current source and current sink variants. Current source sensors supply power to the load, which needs to be referenced to the ground or negative rail of the power supply. In contrast, current sink sensors provide ground to the load, which must be referenced to a positive voltage sharing the same ground.

Certain manufacturers offer AC/DC devices capable of functioning across a broad range of voltages from either power source. These sensors provide the convenience of utilizing a single device across multiple applications with varying power supplies.

Prioritizing Stability and Noise-Free Operation

A recommended practice is to ensure that your sensors or switches receive power from a stable source that is free from noise. This typically involves designating an isolated line or a separate supply specifically for powering the sensors, all while staying within the specified ratings.

Understanding Load Requirements

When evaluating sensors, it's crucial to assess their influence on the connected load. This involves determining the device directly controlled by the sensor and comprehending its attributes. The elements situated between the sensor output and the power or ground collectively constitute the input load for the device and the output load for the sensor. This load transforms the sensor's electrical signals into various energy forms—be it electrical, mechanical, acoustic, or luminous—that consequently trigger alterations in the controlled device.

Characteristics of Load Elements

Various types of circuit elements may form part of the load, each endowed with distinct characteristics:

Resistive elements: These ideal loads dissipate power proportionate to the applied voltage.

Capacitive elements: Reactive in nature, capacitive elements can initially mimic a short circuit upon activation.

Inductive elements: Elements like relay coils and solenoids are also reactive, and when rapidly deactivated, they can generate high voltage transients.

Conditioning the Output

Consider whether the sensor's output requires conditioning to effectively interface with the target device. For swift events, it might be necessary for the sensor or a conditioning circuit to generate a prolonged output pulse that exceeds the event's duration. Additionally, in cases where the sensing function and ensuing action are separated within the system, the output signal might necessitate a time shift.

Understanding the Physical Properties of the Target

For any sensing endeavor, it's imperative to identify the target to be detected, whether it encompasses an entire object or a specific feature of an object. Understanding associated variables like presence, position, orientation, etc., holds key importance, given that these variables wield an impact on the overall process. Environmental conditions must also be taken into account to ensure that the technology remains unaffected, a factor that profoundly influences application reliability.

Target Characteristics and Limitations

Properties of the target, such as size, material, color, and opacity, govern the suitable technology and its constraints. For instance, inductive sensors exclusively detect metal targets, with target size and material exerting influence on sensing range and speed.

The Electrical Interface Circuit: Reliability and Components

The electrical interface circuit, encompassing connections among sensors, power supply, and load devices, holds pivotal importance in ensuring application reliability.

Basic Electrical Interface Circuit

An effective interface adheres to the requirements of application devices while considering environmental conditions. The power supply establishes a shared voltage and current level for all circuit components. Ensuring adequate power delivery to each device for dependable operation is critical, particularly in scenarios where multiple sensors and/or loads are linked via low voltage DC supply. Equally vital is the prevention of any device from receiving excessive current, a common occurrence in improper installations, like direct connections between the sensor output and the power supply or AC line.

Power Supplies and Protection

A recommended practice involves stipulating that switches or sensors draw power from a stable, noise-free source (where noise pertains to undesired energy from other devices or electrical fields). This often entails designating a dedicated line or separate supply for switches and sensors, while maintaining compliance with supply ratings. Additionally, selecting sensors with a certain level of protection against potential power line events, such as short circuits and overloads, is wise.

Available Power Options

Four prevalent industrial sensor power voltages are:

- 12V DC
- 24V DC
- 120V AC
- 240V AC

Sensor Ratings

Industrial sensors typically operate within these voltage ranges:

- 10-30V DC
- 20-130V AC
- 90-250V AC
- 20-250V AC/DC

AC sensors and switches can be directly powered from the main power line or a filtered source, negating the requirement for a distinct power supply. However, most DC sensors necessitate a separate supply to isolate the DC signal from the AC line.

Protection Measures

Irrespective of AC or DC, it is prudent for sensor power to derive from a separate, filtered source, and the line should be fortified with a fuse of an appropriate rating. Nonetheless, this provides limited protection for solid-state devices and sensors within the circuit.

Fast-acting fuses and electronic current-limiting circuits are often insufficient to shield sensors from damage in events like:

- **Short Circuit/Overload**—Lower resistance allows excessive current to reach the device.
- **Reverse Polarity**—Positive and negative wires are improperly connected.

To account for these potential occurrences, opt for sensors equipped with built-in protection against reverse polarity, short-circuit, and overload.

Current Consumption

Typical power consumption for each sensor type:

- Photoelectric: 35mA
- Ultrasonic: 70mA
- Inductive: 15mA
- Capacitive: 15mA

Output Types: Electromechanical and Solid-State

When it comes to output configurations, two main categories exist: electromechanical and solid-state.

Electromechanical Outputs

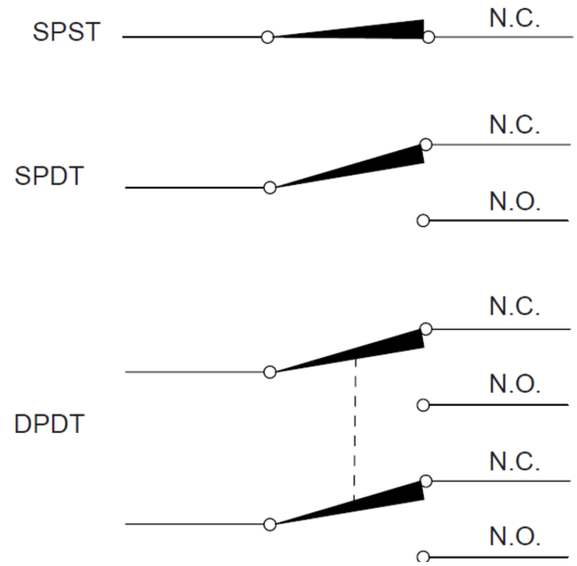
- Relay
- Switch

Solid-State or Electronic Outputs

- Transistor
- Analog
- Field Effect Transistor (FET)
- Triac
- Network or Bus

Your choice of output depends on the interfacing requirements of the application and the available output types for the specific sensor in question.

Electromechanical Outputs



Electromechanical relays (also known as "dry contacts") operate by energizing a wire coil that magnetically draws an armature to physically open and close a circuit. These relays provide electrical isolation from the sensor's power source and can be connected in series and/or parallel to switch AC or DC loads.

Various contact arrangements are available, such as SPST, SPDT, and DPDT. However, relays incorporate mechanical components that wear over time, resulting in response times slower than those of solid-state alternatives.

A simple limit switch serves as an example of a mechanical sensor. Moving the lever on the switch triggers a change in its state. The part that makes contact with the switch induces a state change that the PLC can monitor. Mechanical devices are less reliable compared to electronic counterparts. Mechanical devices are prone to contact wear and can even become welded together. Their actuation is slow, taking time to open and close contacts. Moreover, the contacts can produce chatter upon opening or closing, yielding multiple on and off signals instead of a single clear, timely change of state.

Solid-State Outputs

Electronic devices exhibit considerably faster operation than mechanical devices. Solid-state outputs are particularly suitable for applications requiring frequent switching or handling low voltages and currents.

Solid-state sensors can operate at significantly high production rates, which holds great importance in various automated processes. Conversely, mechanical switches often fall short in terms of speed. Unlike mechanical sensors that necessitate physical contact with the object being sensed, electronic sensors can detect objects without direct contact. Electronic sensors are notably more reliable and can operate for extended periods before experiencing failure. This extended lifespan is critical for maintaining continuous production, as breakdowns are both expensive and time-consuming to diagnose and rectify.

Digital sensors are characterized as on or off devices, sometimes referred to as discrete sensors due to their binary states—either on or off. When a discrete sensor detects an object, its output undergoes a state change. Transistors are commonly used in the output circuit of discrete sensors.

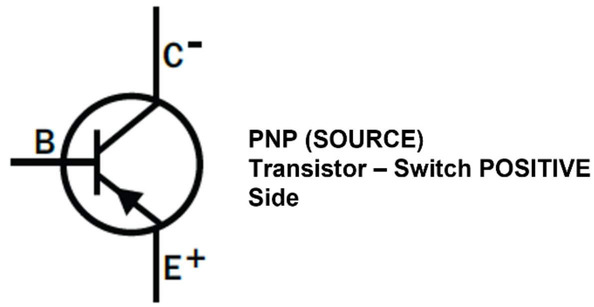
Transistor Outputs (NPN/PNP)

Transistors, which are commonly employed as solid-state outputs for low-voltage DC sensors, serve to electronically amplify or switch current. NPN and PNP transistor outputs differ in connection configurations and are well-suited for DC load switching. These transistors boast minimal leakage current and exhibit response times that span from 30μs to 2ms.

Standard solid-state output devices for low-voltage DC sensors are transistors. Comprising a crystalline chip, typically made of silicon, and three contacts, transistors electronically amplify or switch current. These transistors come in two standard types: NPN and PNP.

PNP

With a PNP transistor, once a negative polarity of sufficient voltage is applied to the Base, a small current flows across the Emitter-to-Base junction. This small current opens the path for the Emitter's positive current to flow to the negative Collector.

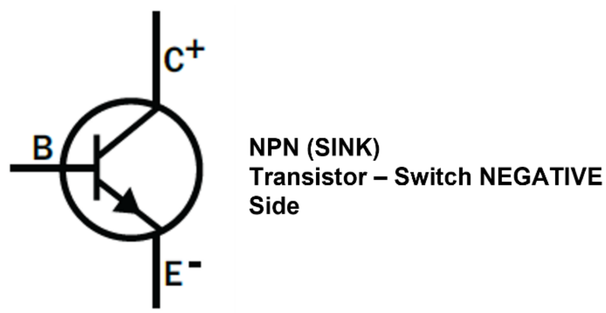


When the transistor's Emitter-to-Collector junction closes, it is effectively a switch completing the circuit on the positive side of the load.

A PNP transistor output follows a 'sourcing' output configuration. In other words, the transistor is sourcing the supplied current flowing to the control device. In this case, the load should be connected between the sensor output and the negative (-) power connection.

NPN

For an NPN transistor, when a positive polarity of sufficient voltage is applied to the Base, a small current will flow across the Base-to-Emitter junction. This small current opens the path for a larger positive current from the Collector to flow to the negative Emitter.



When the transistor's Collector-to-Emitter junction closes, it is effectively a switch completing the circuit on the negative side of the load.

For NPN transistor outputs, the load should be linked between the sensor output and the positive (+) power connection. This arrangement is also known as a 'sinking' output. In other words, the transistor is sinking the supplied current flowing through the control device.

Analog Outputs

Analog output sensors furnish a voltage or current output that corresponds to the magnitude of the detected signal. These sensors prove invaluable when there is a requirement for simultaneous detection of multiple factors, particularly in discrete sensing scenarios.

Analog sensors offer a significantly broader spectrum of information compared to their digital counterparts. Sensors featuring analog outputs deliver a variable output that correlates proportionally to the input signal. For instance, consider a temperature sensor spanning from zero to 500 degrees Fahrenheit; a typical version might produce an output ranging between 4 and 20 milliamps, contingent upon the temperature. With this, an analog sensor can provide an output enabling the controller to precisely discern the state of the input being measured.

The coexistence of digital and analog sensors is essential within industrial applications. While digital sensors are more prevalent due to their cost-effectiveness, simplicity, and user-friendliness, there remain instances where analog sensors are indispensable. These scenarios often involve the need for more comprehensive information about a specific process.

FET, MOSFET, TRIAC, and Network Bus Outputs

Field Effect Transistors (FETs), including Power MOSFETs, offer swift AC or DC power switching with minimal current requirements and low leakage. Power MOSFETs come with the added benefit of high current switching capacity. FET outputs can be connected in parallel, similar to relay contacts. Power MOSFET outputs can effectively manage currents of up to 500mA.

For AC switching, TRIACs are solid-state devices that function analogously to transistors for AC power. They boast high switching current capabilities and exhibit a low voltage drop. However, they do come with higher leakage current. TRIACs necessitate a zero crossing of the AC power sine wave for deactivation. Despite their applications, Power MOSFETs generally offer superior output characteristics.

The concept of network/bus outputs is gaining prominence due to its ability to reduce wiring complexity. Sensors equipped with network interfaces establish communication via a shared backbone cable to the controller. Although this approach is more costly, it simplifies both wiring and debugging processes.

Understanding Limit Switches: Construction, Types, and Applications

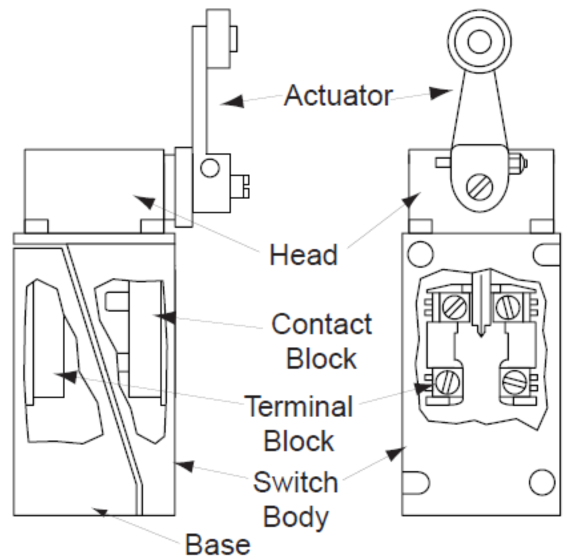
Limit switches are versatile electromechanical devices widely applied in different scenarios owing to their durability, ease of installation, and dependable performance. This discussion will delve into their structure, actuation, and attributes:

A limit switch consists of an actuator connected to contacts, functioning by establishing or breaking an electrical connection when an object interacts with the actuator. These switches serve to determine presence, absence, positioning, and the endpoints of object travel.

Construction of Limit Switches

Limit switches come in two primary body types: plug-in and non-plug-in. They are composed of several essential components:

- **Actuator:** This component makes contact with the sensed object.
- **Head:** It converts actuator movement into contact movement.
- **Contact Block:** Housing the electrical contact elements, it typically contains two or four contact pairs.
- **Terminal Block:** This section holds screw terminations for electrical connections.
- **Switch Body:** For plug-in switches, it houses the contact block; non-plug-in switches combine the contact block and terminal block.
- **Base:** For plug-in switches, it contains the terminal block; non-plug-in switches lack a separate base.



Function and Types of Actuators

The actuator's movement plays a pivotal role in the operation of a limit switch. When force is applied to the actuator, it shifts from an unactuated (rest) position to an actuated position, influencing the switch contacts.

Actuator types include:

- **Side Rotary:** A shaft extending from the side of the head, rotating clockwise or counterclockwise.
- **Side or Top Push:** A rod/button on the side/top of the head, returning to its original position when the force is removed.
- **Wobble Stick or Cat Whisker:** A flexible rod that activates contacts through movement.

Contact Operation and Characteristics

Contacts within a limit switch change state upon the application of force to the actuator. The distinction between maintained and momentary refers to whether the contacts return to their initial position when the force is removed. The categorization of switches into two-circuit or four-circuit devices is based on the number of contact pairs. Additionally, switches can be normally open or normally closed, indicating contact states in the unactuated position.

Advantages and Disadvantages of Limit Switches

Advantages:

- Simple operation
- Durable construction
- Reliable performance in diverse environments
- High resistance to harsh conditions
- Positive opening operation in specific models
- Ability to handle higher power loads
- Immunity to electrical and radio frequency interference

Disadvantages:

- Shorter contact life compared to solid-state technology
- Mechanical parts experience wear over time

Typical Applications

Limit switches are commonly employed in various industrial applications, including: • Conveyor systems

- Transfer machines
- Automatic turret lathes
- Milling and boring machines
- Radial drills
- High-speed production equipment

Understanding Inductive Proximity Sensors: Operation, Construction, and Types

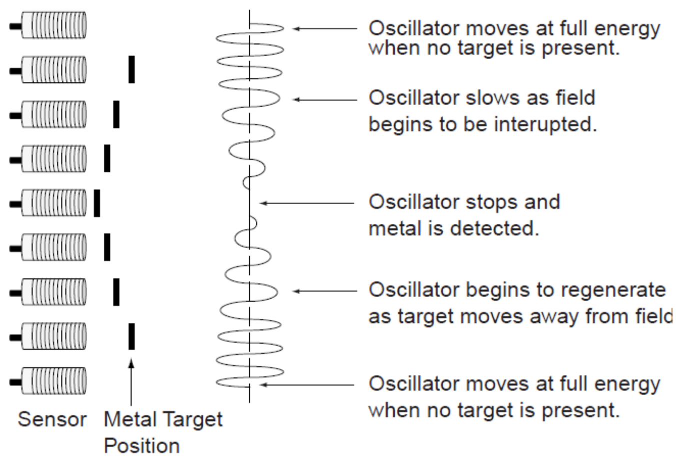
Inductive proximity sensors are invaluable tools designed for the detection of metal objects. Offering a non-contact solution, these sensors are characterized by their robustness and reliability. Let's delve into their operational principles, construction, and the variations that make them versatile in various industrial applications.

Inductive proximity sensors are solid-state devices tailored to excel in the detection of metal objects. Their non-contact nature, coupled with the absence of moving parts, renders them impervious to mechanical wear and damage when properly installed. Furthermore, these sensors exhibit remarkable performance even in highly contaminated environments. Dust, grease, oil, or soot buildup on their sensing surfaces has no effect on their functionality. This adaptability makes them particularly well-suited for demanding industrial environments.

Working Principle and Operation

At the core of inductive proximity sensors lies the Eddy Current Killed Oscillator (ECKO) principle. They generate an electromagnetic field, and when a metal object enters this field, eddy currents are induced within the metal.

These currents diminish the energy within the electromagnetic field, causing a decline in the amplitude of the oscillator circuit. This alteration is detected by the trigger circuit, leading to the switching ON or OFF of the sensor's output.

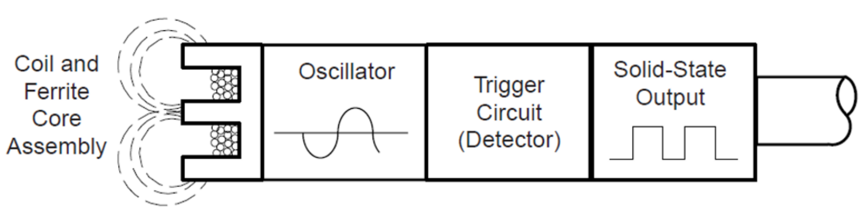


Upon the exit of the object from the field, the sensor promptly returns to its initial state. Importantly, these sensors are adept at detecting both ferrous and nonferrous metals.

Construction of Inductive Proximity Sensors

Inductive proximity sensors are composed of four fundamental components:

- **Coil and Ferrite Core Assembly:** Responsible for generating the electromagnetic field.
- **Oscillator:** Provides the necessary electrical energy to the coil and core.
- **Trigger Circuit:** Detects variations in oscillation amplitude.
- **Solid-State Output Circuit:** Furnishes an electrical signal that indicates the presence or absence of a metal target.



Shielded vs. Unshielded Construction

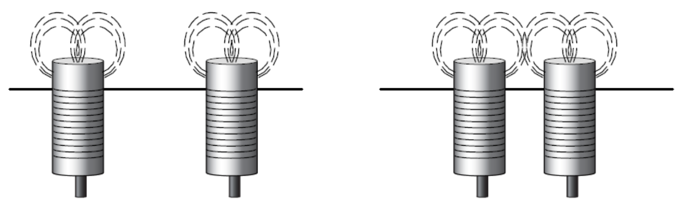
Inductive proximity sensors can be classified into shielded and unshielded constructions, each of which profoundly influences their performance:

Shielded Construction: Shielded sensors feature a protective ring or a metal housing that concentrates the electromagnetic field toward the sensor face. This design facilitates flush mounting within metallic environments without triggering false alarms.

Unshielded Construction: In contrast, unshielded sensors lack metal bands encircling the core/coil assembly. Consequently, they generate a less concentrated electromagnetic field. Unshielded sensors boast a notably larger sensing range, rendering them sensitive to the presence of nearby metals. However, their installation within metal surroundings can lead to false triggers and necessitates strategic spacing to avoid interference.

Spacing Considerations

The proper spacing between sensors plays a pivotal role in avoiding unintended interference. Unshielded sensors, due to their broader lateral field, require a greater degree of separation. Typically, shielded sensors necessitate only one sensor diameter between adjacent units and two diameters for face-to-face placement. In contrast, unshielded sensors mandate three diameters between adjacent sensors and four diameters for face-to-face arrangements.



Correct Incorrect

Applications

Inductive proximity sensors find a myriad of applications across various industries, including:

- Position sensing of metal targets in automated machining.
- Detection of metal parts within automated assembly processes.
- Presence sensing of metal containers within automated food and beverage packaging systems.

Gaining a comprehensive understanding of the principles, construction, and types of inductive proximity sensors empowers efficient and precise utilization within diverse industrial contexts.

Factors Influencing Sensor Performance

The performance of an inductive proximity sensor hinges on several factors that are closely tied to the target and application:

1. **Sensing Range vs. Material and Size of Target:** The Rated Operating Distance (Sn) defines the distance at which a standard target triggers a change in the sensor's output signal. The actual operating distance, however, is impacted by the target's composition, size, and shape within real-world scenarios.
2. **Target Correction Factors:** When dealing with materials other than standard mild steel, correction factors are essential for determining the sensing distances. These factors take into account the target's composition and provide guidance for making distance adjustments.
3. **Effects of Target Size and Shape:** The size and shape of the target are critical considerations. While flat targets are preferable, rounded or nonferrous materials can alter the operating distance.
4. **Manufacturing Tolerances and Variations:** Real-world sensor performance can deviate by up to ±20% from the rated operating distance due to manufacturing tolerances and external factors.
5. **Ferrous and Nonferrous Selection:** Sensors with the ability to detect all metals, ferrous metals, and nonferrous metals behave differently based on their iron content. This adaptability is particularly useful for applications requiring precise metal differentiation.
6. **Object Motion and Switching Frequency:** The motion of the object, whether lateral or direct, affects sensor reliability. While lateral approaches generally enhance reliability due to controlled sensing distances, switching frequency also warrants consideration.
7. **Hysteresis and Weld Field Immunity:** Hysteresis, which refers to the difference between operate and release points, is vital in preventing rapid on-off switching prompted by shocks and vibrations. In environments with high electromagnetic fields, proximity sensors can be optimized for weld field immunity.

Advantages and Disadvantages Inductive Proximity Sensors

Advantages:

- Resilient in moist or dirty environments.
- Free from mechanical wear due to the absence of moving parts.
- Not influenced by color variations.
- Depend less on surface characteristics compared to other sensor types.
- Eliminate the occurrence of blind zones.

Disadvantages:

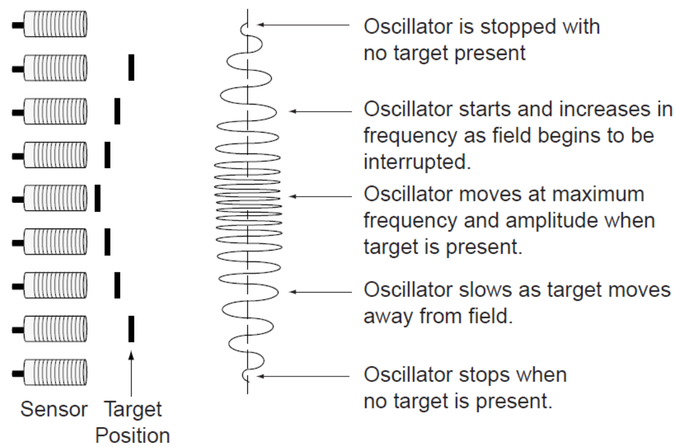
- Exclusive detection of metal targets.
- Limited operating range compared to certain other sensor types.
- Vulnerable to the influence of strong electromagnetic fields.

Understanding Capacitive Proximity Sensors: Principles, Construction, and Advantages

Capacitive sensing, a noncontact technology, stands out for its ability to detect a wide range of materials, including metals, nonmetals, solids, and liquids. While effective for both metallic and nonmetallic targets, capacitive sensing particularly excels in nonmetallic scenarios due to its unique attributes and cost-efficiency relative to inductive proximity sensors. However, in applications involving metallic targets, inductive sensing is often preferred for its reliability and affordability.

Operational Principle and Construction

Capacitive proximity sensors share similarities in size, shape, and concept with their inductive counterparts, yet their underlying mechanism differs.



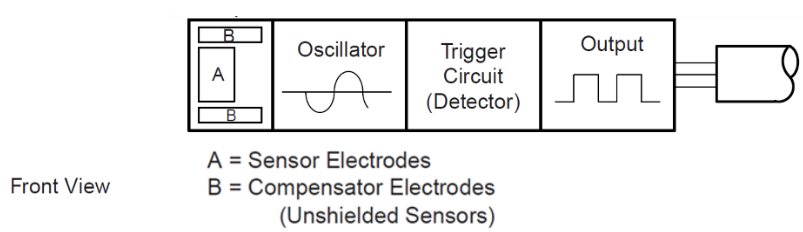
While inductive sensors rely on induced magnetic fields, capacitive sensors respond to changes in an electrostatic field. Behind the sensor face, a capacitor plate acts as a probe. The application of power generates an electrostatic field that reacts to variations in capacitance caused by nearby targets.

When a target enters this field, a capacitive coupling forms between the target and probe, activating the sensor's oscillator. Once the capacitance reaches a specific threshold, the output circuit switches between ON and OFF states. The sensor's effectiveness is influenced by the target's size, dielectric constant, and distance.

Construction of Capacitive Proximity Sensors

Capacitive proximity sensors consist of key components:

- **Capacitive Probe or Plate:** Emits an electrostatic field, interacting with the target.
- **Oscillator:** Supplies electrical energy to the capacitive probe.
- **Trigger Circuit:** Detects changes in oscillation amplitude caused by the target's presence.
- **Solid-State Output Switching Device:** Generates an electrical signal indicating the presence of a target.
- **Adjustment Potentiometer:** Controls sensitivity.



Shielded vs. Unshielded Construction

Capacitive proximity sensors can be classified into shielded and unshielded constructions, each of which profoundly influences their performance:

Shielded Construction: Shielded sensors feature a metal band around the probe, concentrating the electrostatic field. This design allows flush mounting without false triggers. Ideal for low dielectric constant materials, they detect targets that unshielded sensors might miss.

Unshielded Construction: Unshielded sensors lack the metal band, resulting in a less focused electrostatic field. Some models come with compensation probes for improved stability. They are suitable for plastic sensor wells and excel in detecting high dielectric constant materials. Unshielded models with compensation probes resist mist, dust, and minor liquid accumulation.

Target Considerations

Similar to inductive sensors, capacitive sensors use a standard target for reference. This standard target is a 1mm thick square mild steel piece, with sides equal to the active face diameter or three times the nominal switching distance, whichever is larger. Despite IEC test standards grounding the standard target, real-world applications don't require grounding for reliable sensing.

Dielectric Constants

The sensitivity of capacitive sensors hinges on the dielectric constant of the material being detected. Higher dielectric constants make materials easier to sense, while lower values present challenges.

For example, water with a dielectric constant of 80 is easily detected, making capacitive sensors ideal for liquid level sensing. In contrast, air with a dielectric constant of 1 is not sensed. Materials like wet wood (dielectric constant between 10 and 30) or dry wood (between 2 and 6) fall within the sensor's sensitivity range.

Notably, materials with higher dielectric constants can be detected through containers with lower dielectric materials, broadening their application possibilities.

Environmental Considerations

Capacitive sensors can react to mist, dirt, dust, or contaminants on the sensor face, leading to unintended output signals. Compensation electrodes stabilize unshielded sensors by creating a compensation field that enhances sensor stability. However, this compensation field's reach is limited. When contaminants affect the sensor face, both the sensor and compensation fields are impacted, resulting in no output change due to the proportional increase in capacitance.

Advantages and Disadvantages of Capacitive Proximity Sensors

Advantages:

- Detects metals, nonmetals, liquids, and solids.
- Can penetrate certain materials, like product boxes.
- Offers solid-state reliability and longevity.
- Supports various mounting configurations.

Disadvantages:

- Short sensing distance (1 inch or less) varies with the sensed material.
- Sensitive to environmental factors, such as humidity in coastal areas.
- Lacks selectivity for its target, necessitating control over objects near the sensor.

Understanding the intricacies of capacitive proximity sensors and their interaction with different materials enables their effective application in diverse scenarios, catering to specific sensing needs.

Diverse Applications of Capacitive Proximity Sensors

Capacitive proximity sensors are widely utilized in various industries, offering dependable solutions for intricate detection demands. Here, we present illustrative examples of these applications:

1. **Liquid Level Sensing** Capacitive proximity sensors excel at accurately monitoring liquid levels in scenarios such as:
   - Measuring batter in food processing or ink in printing applications through sight glasses.
   - Placing sensors within sealed tubes in drums or holding tanks for chemicals or aqueous solutions.
2. **Product Filling Lines** Capacitive sensors play a pivotal role in product filling lines, ensuring precision and efficiency in operations like:
   - Filling bottles, including liquids such as shampoo.
   - Verifying complete cases by detecting the correct number of products in containers.
   - Ensuring accurate material levels, such as quantities of cereal within boxes.
3. **Plastic Parts Detection** Capacitive sensors are adept at identifying plastic components, offering benefits like:
   - Detecting plastic elements on product packaging, like spouts on laundry detergent boxes.
   - Identifying plastic materials within hoppers or other containment structures.
4. **Pallet Detection for Materials Handling** In materials handling and logistics, capacitive proximity sensors contribute by:
   - Detecting the presence of pallets, enhancing smooth handling and logistics operations.

5. **Irregularly Shaped Products** Capacitive sensors prove invaluable for intricate scenarios involving irregularly shaped objects:
    - Identifying objects placed randomly on conveyor belts, regardless of their orientation.
    - Precisely detecting highly textured objects, overcoming challenges posed by intricate surfaces.

By highlighting these applications, the inherent versatility of capacitive proximity sensors in addressing diverse sensing requirements becomes evident. With their reliability and adaptability, these sensors prove essential across industries, ensuring seamless operations and accurate detection.

Understanding Photoelectric Sensors: Principles and Applications

Photoelectric sensors are versatile devices that employ light beams to replace mechanical actuators for a wide range of sensing tasks. These sensors operate by detecting changes in light levels received by a photodetector, enabling them to sense object presence, absence, size, shape, reflectivity, opacity, translucence, or color. Their applications span from short distances of less than 2.54 cm (1 in) to extended ranges of hundreds of meters.

Operational Mechanism

A photoelectric sensor emits a light beam, either visible or infrared, from its light-emitting element. Two main types are used for detection:

Reflective-Type: This sensor detects the light beam reflected from the target.

Thru-Beam Type: This sensor measures the change in light quantity caused by the target crossing the optical axis.

Optical Sensors and LED Emission

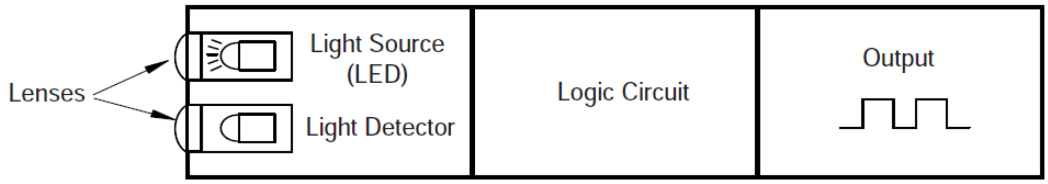
Optical sensors, commonly referred to as photo sensors, utilize a light source emitter and a photo detector to sense the presence or absence of light. LEDs (Light Emitting Diodes) serve as the light source, emitting light with various colors, including infrared, visible red, green, and blue. The choice of LED material determines the wavelength of the emitted light. LEDs offer rapid on-off capabilities, making them suitable for high-speed production applications. Additionally, they are reliable, small, energy-efficient, and immune to shock, temperature, and vibration.

Ambient Light Immunity

Photo sensors are immune to ambient light interference due to their frequency-tuned photoemitter and photo receiver. They operate at frequencies invisible to the human eye, minimizing interference from other lighting sources in the environment. For applications requiring color differentiation, color mark sensors leverage this ability to detect different wavelengths.

Components of Photoelectric Sensors

- **Light Source:** Typically an LED emitting specific wavelengths.
- **Light Detector:** Utilizes photodiodes or phototransistors to detect light changes.
- **Lenses:** Shape the light area for enhanced sensing range.
- **Logic Circuit:** Modulates the LED, amplifies the signal, and controls output.
- **Output Device:** Activates an output signal based on light variations.

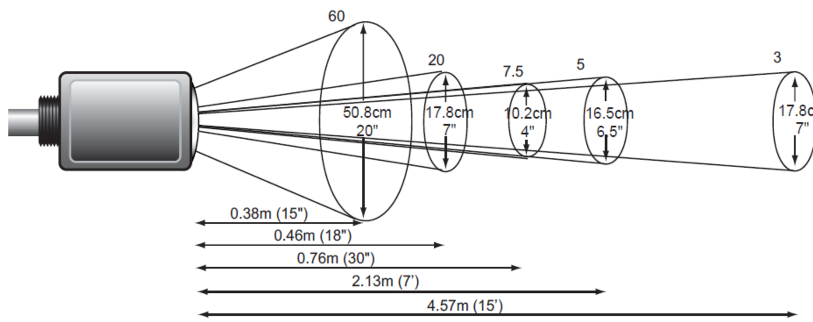


Photoelectric Sensors Terminology

Field of View and Sensing Distances

Sensors vary in field of view, optimized for long sensing distances with narrow fields or broader areas with shorter ranges.

The field of view can be described like a garden hose with a nozzle on the end. As the spray is adjusted, a longer range is achieved using a narrow spray/beam. When the spray/beam is widened the maximum distance decreases.



Manufacturers provide conservative sensing distance ratings due to environmental factors. Shorter distances ensure reliability.

Margin: A margin of at least 2X between detected light and the minimum needed to trigger output is recommended for industrial environments.

Beam Patterns and Effective Beam: While not perfectly shaped, beam patterns illustrate the detection area, detecting reflective targets within. The light area between emitter and receiver lenses constitutes the effective beam, varying based on sensing mode.

Hysteresis: Photoelectric sensors exhibit hysteresis, the difference between detecting and not detecting a target, useful in challenging conditions.

Response Time: The time between target detection and output change varies between sensors and is critical in relation to object speed.

Light and Dark Sensing

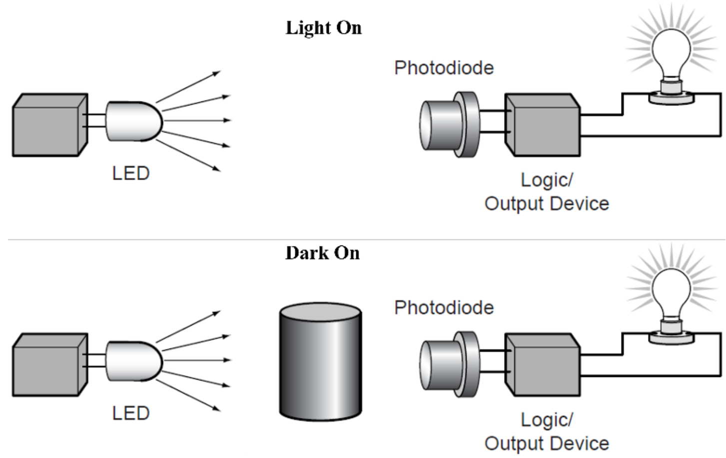
In photo sensors, the terms "light on" and "dark on" describe the output states.

"Dark on" means the output is active when there's **no light at the receiver**.

"Light on" signifies that the output is active when there's **light at the receiver**.

Photo sensors come in either light on or dark on sensing configurations, and some sensors even allow switching between these modes.

This versatility caters to different application needs.

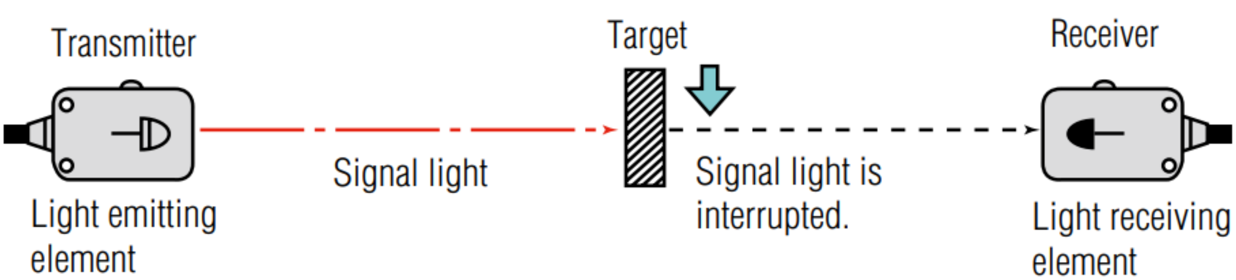


Sensing Modes:

When it comes to sensor applications, a critical step is selecting the appropriate sensing mode. In photoelectric sensors, three primary sensing modes exist: Transmitted Beam, Retroreflective, and Diffuse. Each mode boasts its own strengths and weaknesses, and the choice hinges on specific application needs.

Transmitted Thru-Beam Mode

In the Transmitted Thu-Beam mode, the emitter and receiver are separated, with the light source directly shining from the source to the receiver. Detection occurs when the light beam is interrupted by an object. This mode is highly reliable for non-transparent objects and offers the longest sensing distances. It excels in dusty or dirty environments, ensuring reliable detection even with up to 99% of the lens area contaminated.



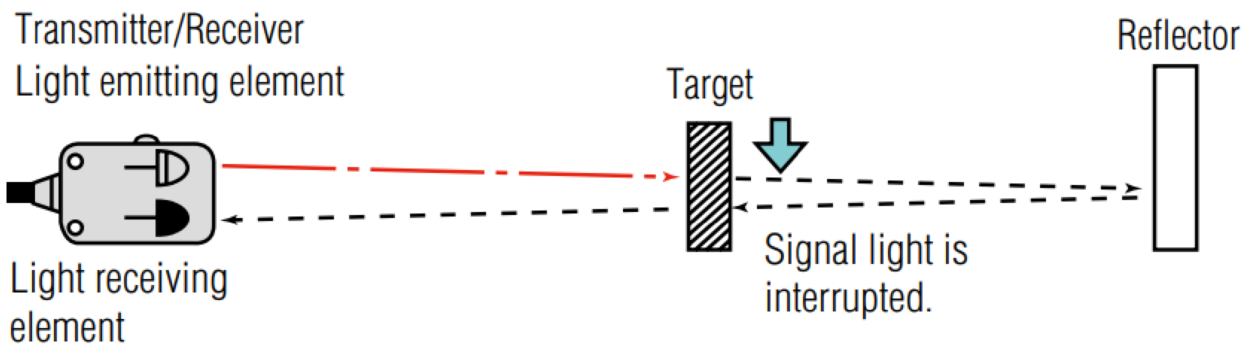
Advantages and Disadvantages of Transmitted Thru-Beam:
Advantages:

- Suitable for a wide range of applications.
- Reliable for accurate parts counting.
- Unaffected by surface reflectivity or color.
- High margin for detection.

Disadvantages:

- Can detect through thin opaque materials at close range.
- Challenging for objects smaller than 50% of the beam.

Retroreflective and Polarized Retroreflective Modes
In these modes, the emitter and receiver are combined in a single housing, with a reflector bouncing the emitted light back to the receiver. Polarized Retroreflective mode adds polarizing filters to focus light into a single plane, excluding reflective objects. This mode is ideal for situations where reflective backgrounds or shiny objects are present, such as conveyor applications.



Advantages and Disadvantages of Retro-reflective:
Advantages:

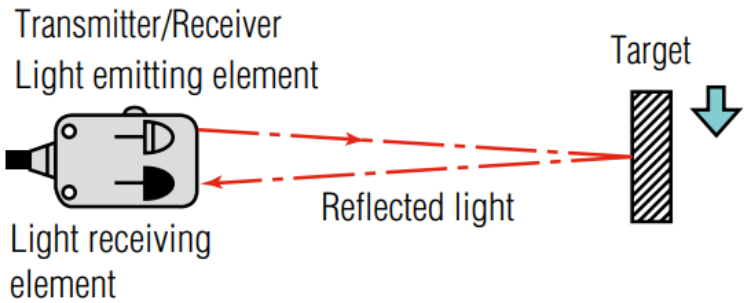
- Useful for sensing reflective backgrounds.
- Polarized Retroreflective avoids sensing shiny objects.
- Ideal for conveyor applications.

Disadvantages:

- Shorter sensing distances compared to Transmitted Beam.
- Less margin for Polarized Retroreflective due to light losses.
- May not be suitable for precise positioning or small parts detection.

Diffuse Mode

In Diffuse mode, the light emitter and receiver are housed in the same unit. The emitter sends light to the product, which reflects it back to the receiver, triggering the sensor's output. Diffuse mode relies on the scattering of light from the object's surface.



Various types of Diffuse sensing exist, including:

- Sharp Cutoff
- Background Suppression
- Fixed Focus
- Wide Angle

Advantages and Disadvantages of Diffuse:

Advantages:

- Appropriate for short to medium distances.
- Suitable for monitoring surface conditions based on reflectivity.
- Various options for specific applications.

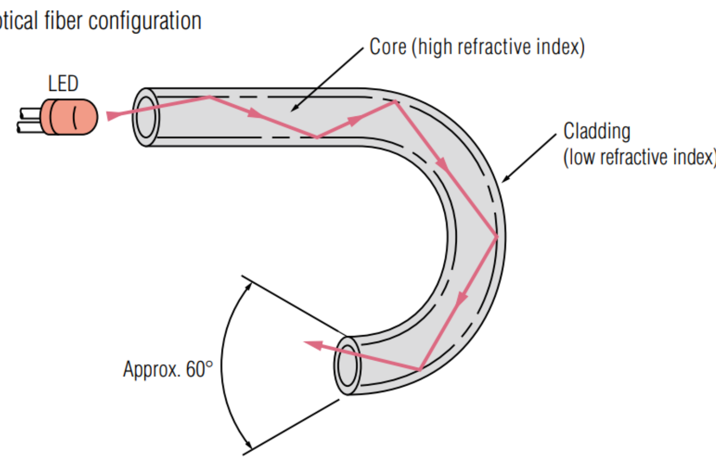
Disadvantages:

- Response influenced by object reflectivity.
- Challenging with shiny or dark objects.
- Limited reliability for accurate parts counting.

Each sensing mode presents distinct pros and cons. To make the right choice, it's important to understand your application's requirements and the environmental factors at play.

In summary, photoelectric sensors offer diverse applications and robust functionality in various industries, thanks to their light-based sensing capabilities and advanced components. Understanding their principles equips professionals to deploy them effectively for precise and reliable detection tasks.

Fiber Optic Sensors



Fiber optic sensors are available in the same configurations as other photo sensors: reflective, retroreflective, and through-beam.

Fiber optic cables are available in two materials: glass and plastic.

- Glass fibers, bundled in a flexible sheath, offer durability and resistance to high temperatures.
- Plastic fiber optic cables, typically made from a single acrylic monofilament, are more affordable and suitable for applications requiring cable flexibility.

The emitted light travels through the fiber and exits from the opposite end. Conversely, light enters through one end of the fiber and is sensed by the receiver at the other end.

A notable advantage of fiber optic sensors is their suitability for applications with limited space. The compactness of fiber cables enables the placement of sensor electronics in separate locations with more available space. Additionally, due to their small size, fiber cables can direct light to precisely sense objects even in confined spaces.

Advantages and Disadvantages of Fiber Optics

Advantages:

- Resilient under extreme ambient conditions with remote-mounted electronics.
- Ideal for sensing small objects.
- Easily installed in confined areas.
- Fiber sensing tips can replicate most sensing modes.

Disadvantages:

- Plastic fibers work best with visible red sensors.
- Glass fibers can be damaged by frequent or extreme cable movement.
- Limited sensing range.
- Susceptible to sensing reliability issues due to ambient contamination.

By integrating fiber optic sensors into your sensing strategy, you can overcome traditional limitations and achieve superior performance in challenging environments.

Vision Sensors

Vision sensors play a crucial role in manufacturing and quality control by assessing the presence, orientation, and accuracy of parts through camera-captured images. Unlike image inspection systems, these sensors stand out for their integrated design, encompassing the camera, light source, and controller within a single unit. This streamlined design simplifies both construction and operation.

Compared to general-purpose sensors, vision sensors offer distinct advantages. They possess the capability to perform a variety of tasks, including multi-point inspections. Their wide-field-of-view images enable reliable detection even when target positions vary.

Vision Sensor Operation

- The sensor head's camera captures an image.
- The captured image travels through the lens.
- The light-receiving element, typically a CMOS sensor, converts the image into an electrical signal.
- Analysis is carried out based on pixel-level light/darkness and intensity information to determine the target's brightness and shape.

Vison Color Modes

Unlike monochrome sensors that only identify white-to-black intensity, the light-receiving element can be color-type. With RGB separation, the color-type sensor can identify intensity ranges for red, green, and blue, making it possible to differentiate even subtle color variations.

Advantages of Visions Sensors

A key advantage of vision sensors lies in their capability to detect not only individual "points" but entire "surfaces." This means they can:

- Detect multiple targets simultaneously.
- Identify multiple items on each target.
- Effortlessly switch between detection targets.

All of these scenarios can be managed using a single sensor. Additionally, the flexibility to add tools later supports easy adaptation to evolving inspection requirements through simple adjustments. This adaptability ensures that your inspection processes remain robust and effective over time.

Understanding Two-Wire and Three-Wire Sensor Configurations

Sensors come in two main configurations: two-wire and three-wire types. The two-wire sensors are referred to as load-powered sensors, while the three-wire sensors are known as line-powered sensors.

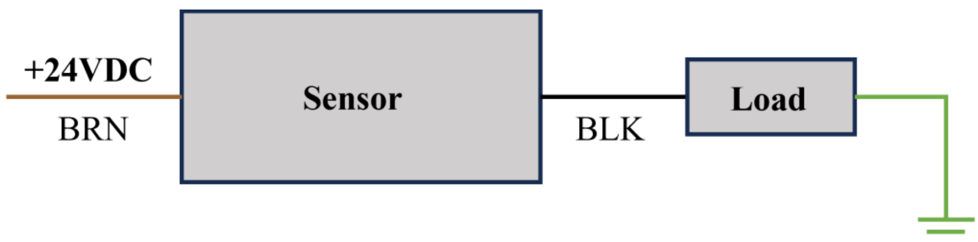
Typically for sensors, there are usually 3 or 4 colored wires that indicate how to install the device.

- **Brown** is for 24VDC
- **White** is an output of the sensor (Load)
- **Blue** is for 0VDC
- **Black** is an output of the sensor (Load)

*The use of the black and white wires is dependent on the function of the device. The black wire is commonly used as the load of the device.

Load-Powered Sensors (2-Wire)

Load-powered sensors are categorized as two-wire sensors. In this setup, one wire is connected to the power source, and the other wire is connected to one of the load wires. The load, which is the device being monitored for output, often corresponds to a PLC input.



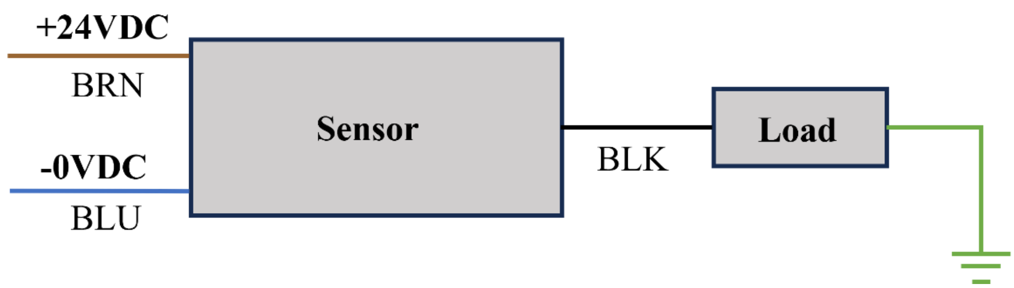
It's crucial to ensure that the load limits the output current to a safe level for the sensor, as excessive current can damage the sensor's output.

In a load-powered sensor arrangement, the current needed for the sensor's operation flows through the load. Think of the load as analogous to a PLC input.

A small current must be allowed to pass through to activate the sensor's operation. This current, known as leakage current, is typically under 2 milliamps. While it's enough to enable the sensor, it's usually insufficient to trigger the PLC input directly. If the leakage current is capable of activating the PLC input, connecting a bleeder resistor becomes necessary. When the sensor activates, it allows enough current to flow, thus turning on the PLC input.

Line-Powered Sensors (3-Wire)

Line-powered sensors typically consist of three wires: two for power and one for the output signal. The load is connected to the output signal, usually a PLC input. It's important to ensure that the load current remains within acceptable limits.



The load current represents the output from the sensor. When the sensor is on, there is a load current, and this load current activates the PLC input. The maximum load current generally falls between 50 and 200 milliamps for most sensors. Properly controlling the load output current is crucial to prevent damage to the sensor. It's worth noting that even if the output LED on a sensor is functional, the output itself might still be faulty.

Wiring diagrams can usually be found on the sensor or associated devices. Refer to your specific PLC's documentation for precise wiring instructions for your device and for accurate wiring guidance, consult the manufacturer's installation sheet for your specific device.

Sensor Selection

Step 1: Identifying Processes and Events

Operational systems encompass a variety of processes, such as fabrication, assembly, packaging, painting, and material handling. Within each of these processes lie smaller events, like counting, indexing, ejection, spraying, filling, and conveying. The value of utilizing sensors becomes evident when detecting the dynamic conditions associated with these actions and events.

Step 2: Defining System Functions

The subsequent step involves identifying critical operations within the system. This entails singling out specific areas that demand verification.

Step 3: Determining Desired Outcomes

Define the actions executed by the system or the outcomes it aims to accomplish. Do you require tracking product quantities, sorting items, conducting quality checks, or establishing part orientation? Reflect on these particulars:

- What prerequisites must be met before each function can occur?
- What feedback is indispensable during the execution of each function?
- What conditions need to be satisfied after a function to ensure proper execution?

Step 4: Focusing on Action Areas

Now, narrow your attention to the particular regions where actions unfold. This typically involves both a workpiece and an associated mechanism. Probe into both aspects to grasp the prerequisites for effective function execution.

Validating the workpiece: Are specific features or components of the workpiece necessary or should they be oriented in a certain way? Could the workpiece possibly undergo incorrect orientation or incur damage that might impede the process?

Confirming the mechanism: Does the mechanism or workpiece rely on separate systems that might collide if one is present without the other being retracted? Is any particular component susceptible to breakage or wear?

Determining Sensor Applicability

Step 1: Assessing Importance and Impact

Initiate the process by evaluating the significance of the identified areas within the operational sequence. The extent of automation is directly linked to the significance of ensuring accurate function execution. Specifically, ask yourself:

- What are the repercussions of damage or loss?
- How likely is such an event to occur?
- What kind of impact does it impose on the overall process integrity?

If any of these questions yield a "high" response, it becomes imperative to consider integrating a sensor to monitor conditions that could potentially lead to a disruption in the system.

Step 2: Defining Sensing Functions and Locations

Moving forward, the subsequent stage involves outlining the required sensing functions and identifying optimal locations for their implementation. Are you seeking to detect system jams, enforce high/low limits, aid in sorting, measure speed, or establish part positioning? This not only determines the sensor placements but also addresses specific physical constraints. Additionally, consider the following:

Safety and Economic Factors:

If failing to detect a condition could result in injury, fatality, or significant financial loss, earmark the matter for the attention of experts specialized in those specific applications.

Optimal Sensing Locations:

In numerous cases, the final outcome of a sequence of operations holds paramount importance. Monitoring this ultimate outcome frequently offers insights into the accurate execution of preceding actions. In certain scenarios, spatial limitations might restrict direct detection within the primary area, but a more dependable sensing function could be performed during transit or earlier stages of the process.

Step 3: Defining the Application

Having recognized an application that stands to benefit from sensor integration for monitoring dynamic conditions, shift focus to determining:

- Available power resources
- Output and load requirements
- Characteristics of the target

Environmental Factors and Target Differentiation

Comprehending the impact of environmental factors on the target, background, and surroundings is of paramount importance. Ideally, the changing condition of the target you intend to detect should stand out from related elements within the background and surroundings. To illustrate, when identifying color changes, light is employed. However, a photoelectric sensor that utilizes light to detect color alterations might encounter challenges if the surroundings are too opaque to allow light transmission or if the background reflects more light than the target.

Selecting the Appropriate Sensor

Having documented the application and identified the detection requirements, the focus now shifts to sensor selection. This step entails determining which technology or technologies effectively harness the unique attributes of the changing condition while minimizing susceptibility to background and surroundings. Rarely does a singular solution exist; each technology boasts strengths and weaknesses that dictate its suitability for a specific application. To make an informed decision, it's essential to adopt a comprehensive perspective of the entire system and then gradually narrow down to specific processes.

Enhancing the Process with Sensors

Contemplate how a sensor could augment each process and contribute to the holistic system. Compare the insights garnered from this approach with the information pertaining to available sensor types. This comparative analysis will assist in pinpointing the most fitting sensor for the application. Ultimately, the chosen solution should strike the optimal balance among performance, reliability, availability, and cost.

Lab 05 – Establishing an IP Address on a Personal Computer

Objective:

The objective of this lab is to guide students through the process of establishing a static IP address on a personal computer.

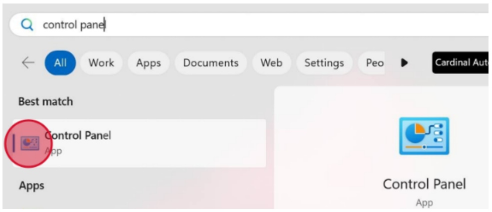
Equipment and Software:

- Personal computer with Windows operating system (Windows 10 or later recommended)
- Ethernet cable (optional, for wired connection)

Note: This lab exercise involves making changes to network settings, which could affect your computer's network connectivity. Follow the instructions carefully, and if you encounter any issues, you can reset the settings to their previous state.

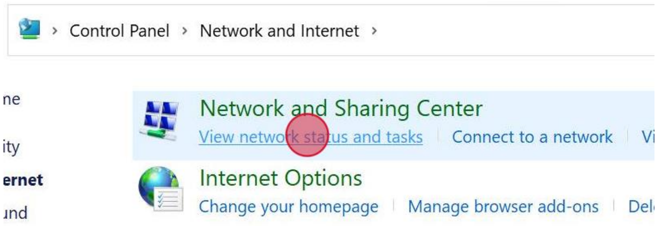
Lab Task:

1. Open the **Control Panel** by using the Main Menu or Search Bar

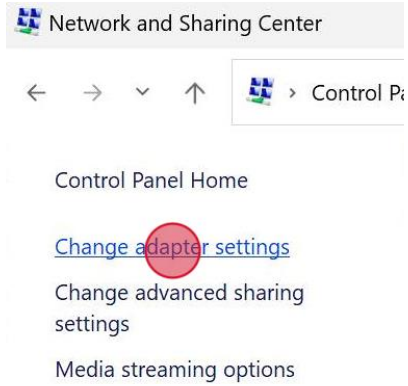


2. Click **Network and Internet**

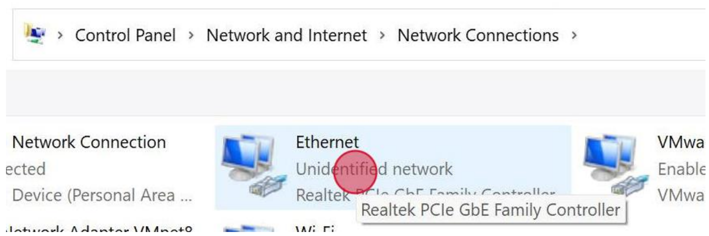
3. Click **Network and Sharing Center**



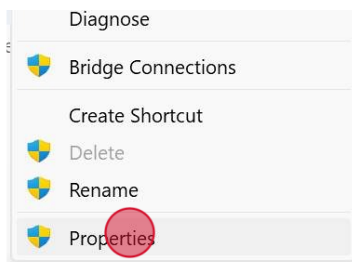
4. Click **Change adapter settings** in the left pane.



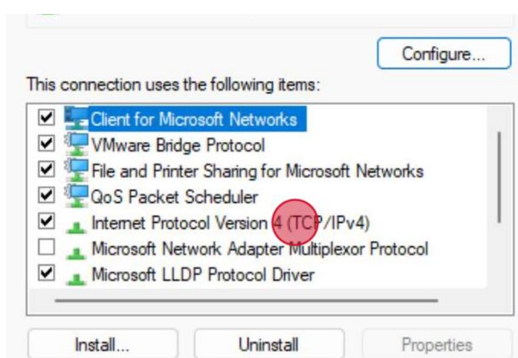
5. On this computer, the adapter with the name **Ethernet** indicates Unidentified Network.



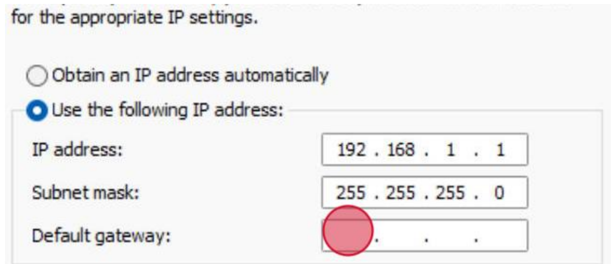
6. Right-click on Ethernet and select **Properties**.



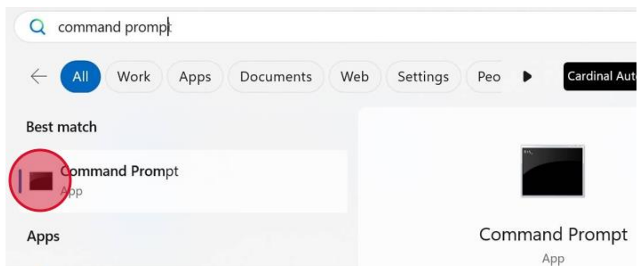
7. To configure the IP address, double-click **Internet Protocol Version 4**.



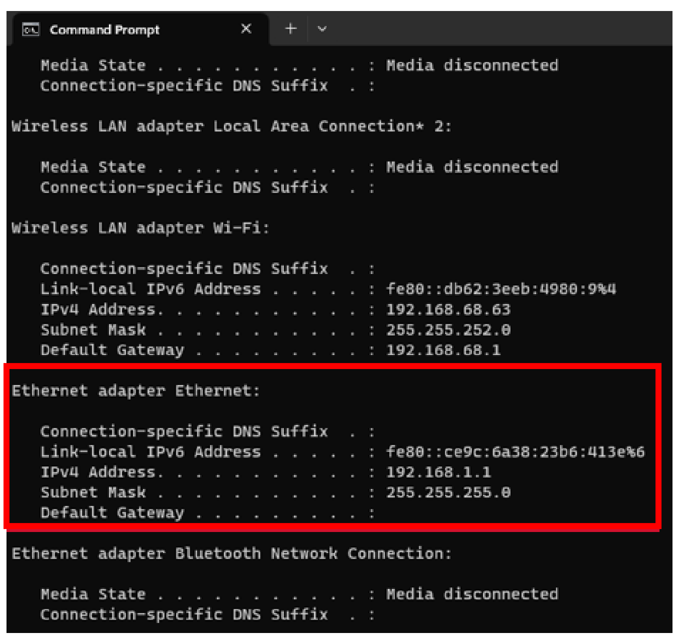
8. On the General tab, the default setting is typically set to Obtain an IP address automatically. **Select Use the Following IP address**. Set the host IP address.



9. **Verify** the IP Address of the computer. In the **Start Menu** or **Search Bar**, type and select **Command Prompt**.



10. Type **ipconfig** – verify the IP address is correct. The IP address that was set in the previous step, should appear under Ethernet adapter.



11. This is the end of the lab exercise. Check with your instructor to verify the completion of the lab.

Cardinal Automation, LLC

About Us

Cardinal Automation, LLC was created by former university instructors and industry professionals to provide custom automation training and equipment to meet the needs of your program.

Cardinal Automation, LLC is committed to providing a quality training platform to those looking to expand their knowledge in industrial automation.

- Our courses offer a concise curriculum taught online and in-person through step-by-step guides to teach real-world industrial equipment.
- We provide custom training options to assist the employees in your facility.
- The automation trainers we build are constructed with industrial grade components that will bridge the gap to industry.

Reach Us

A PO Box 3111, Elida, OH 45807
P 419-270-7684
E contact@cardinalautomation.co
W www.cardinalautomation.co