## Week-6: Day -2

## Session-3

**Implement/Simulate a Counter to count the object detected on the conveyor at the packaging department with any of below process and update onto PLC**

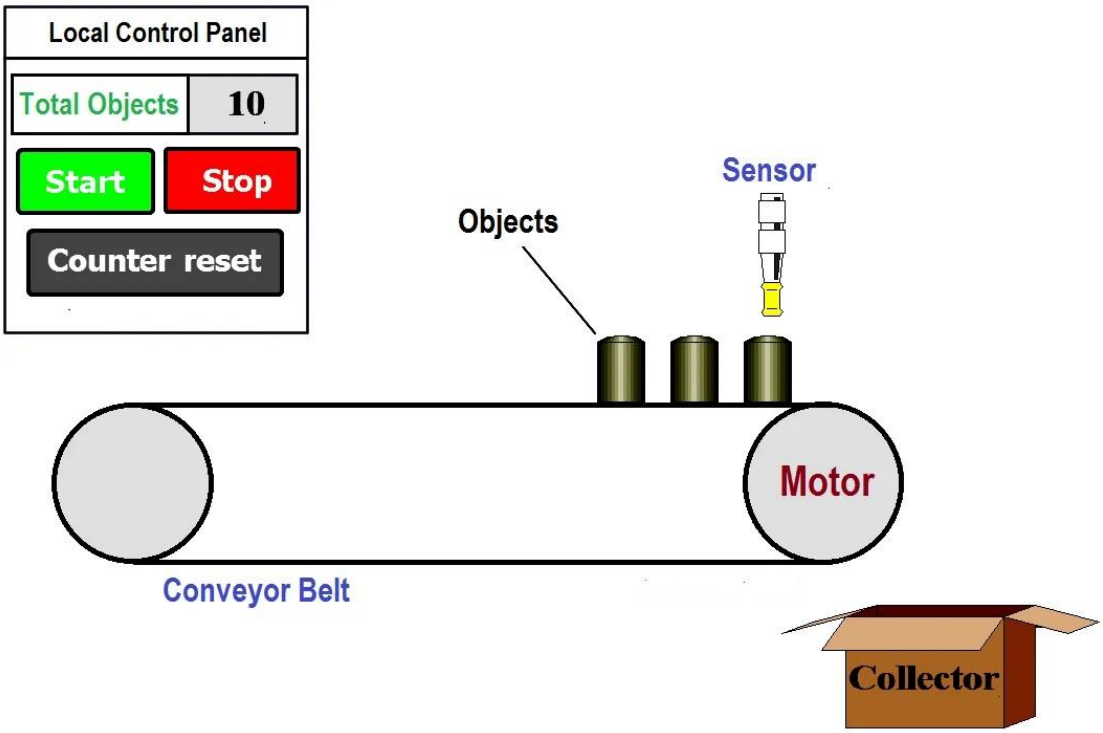
- **Metal Detector Sensor with PLC**
- **Plastic Detector Sensor with PLC**
- **Distance measurement sensor integrating with PLC**
- **Color Detection sensor with PLC.**
- **Magnetic sensor with PLC**

# 6.3.1 Implement a Counter to count the object detected on the conveyor at the packaging department using Proximity IR sensor and update onto PLC.

### 6.3.1.1 Problem Description

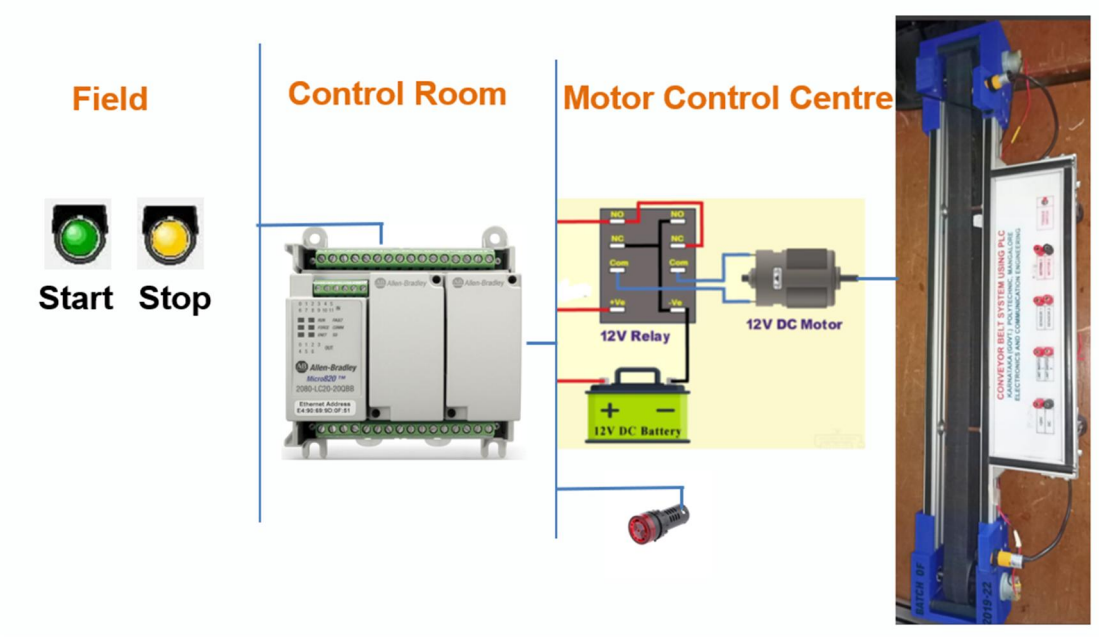
- **Implement a Counter to count the object detected on the conveyor at the packaging department using Proximity IR sensor and update onto PLC.**
- Objects are moving on the conveyor. We need to count the total number of objects collected at the end of conveyor and display it on counter block. Write PLC program for this application.

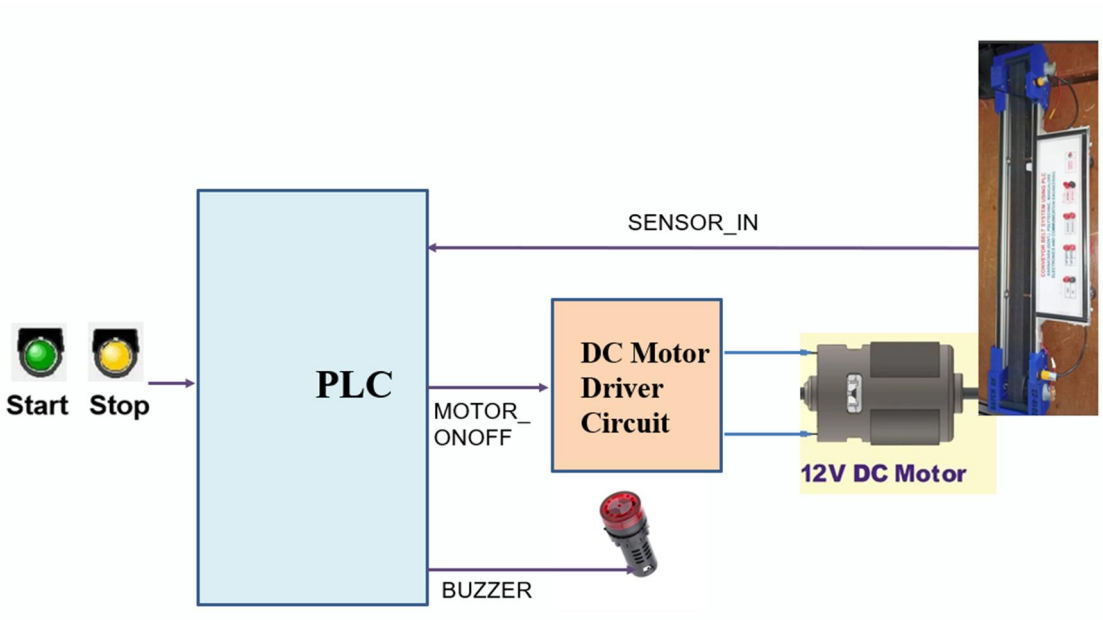
### 6.3.1.2 Problem Diagram




### 6.3.1.2 Problem Solution

- Here we use PLC ladder program to implement this logic.
- Mostly proximity sensors are used to detect the objects. Here we mount proximity sensor to detect the parts or objects moving on the conveyor.
- Inductive sensor is mostly used to detect metal objects. For other type of objects, we use Capacitive proximity sensor for detecting the objects moving on the conveyor.
- In our conveyor kit IR proximity sensor used to detect the object. We connect this sensor to the PLC and by using counter logic, we will count the number of objects and display the total number on the counter block.
- Here we use UP counter for counting the collected Objects at the end of conveyor.
- After 10 objects a beep sound we can here from buzzer. After reset, operation revoked once again.




### 6.3.1.3 List of Inputs and Outputs

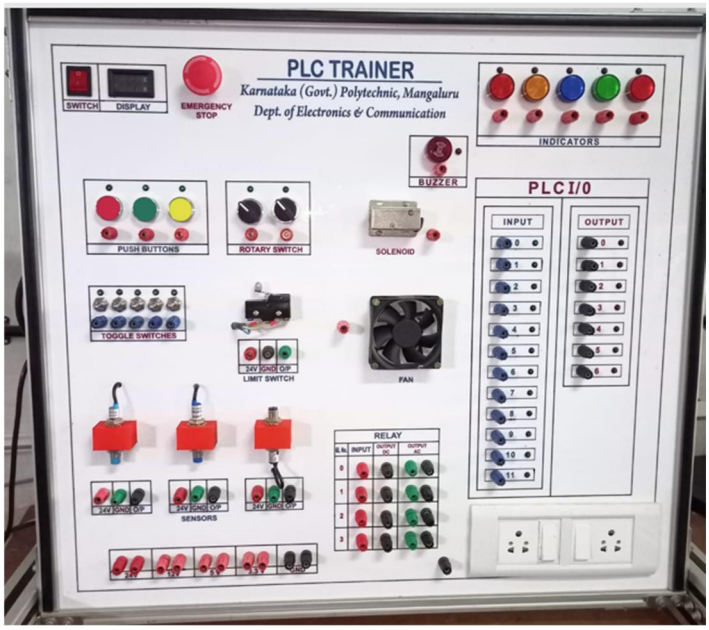
- **PLC Inputs List**

| Sl. No. | Input Name | Micro 820 I/O Address |
|---|---|---|
| 1 | START | _IO_EM_DI_00 |
| 2 | STOP | _IO_EM_DI_01 |
| 3 | SENSOR_IN | _IO_EM_DI_02 |

- **PLC Output List**

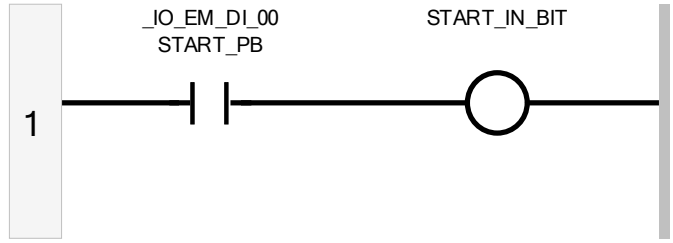
| Sl. No. | Output Name | Micro 820 I/O Address |
|---|---|---|
| 1 | MOTOR_ONOFF | _IO_EM_DO_00 |
| 2 | BUZZER_OUT | _IO_EM_DO_01 |

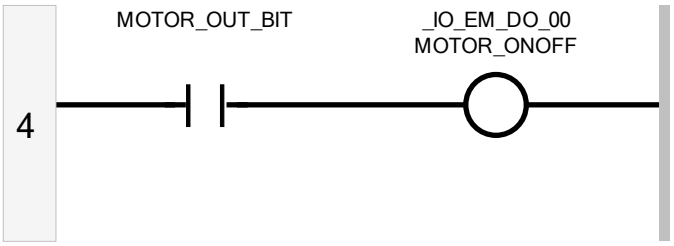
### 6.3.1.4 Experimental Setup

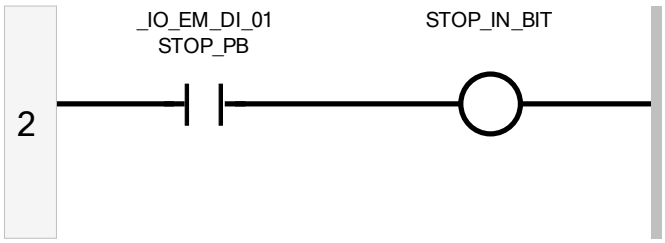


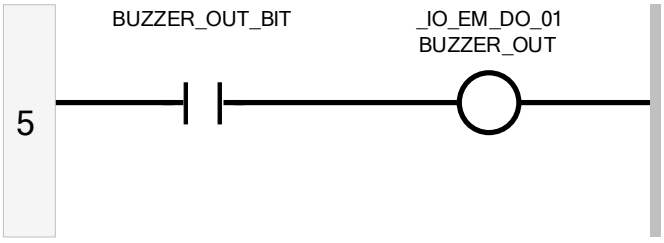

### 6.3.1.5 PLC Ladder diagram:

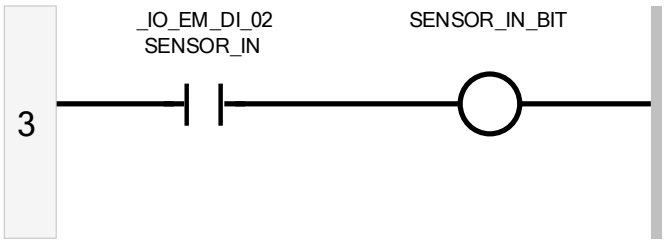
### Conveyor Belt - Input_Output



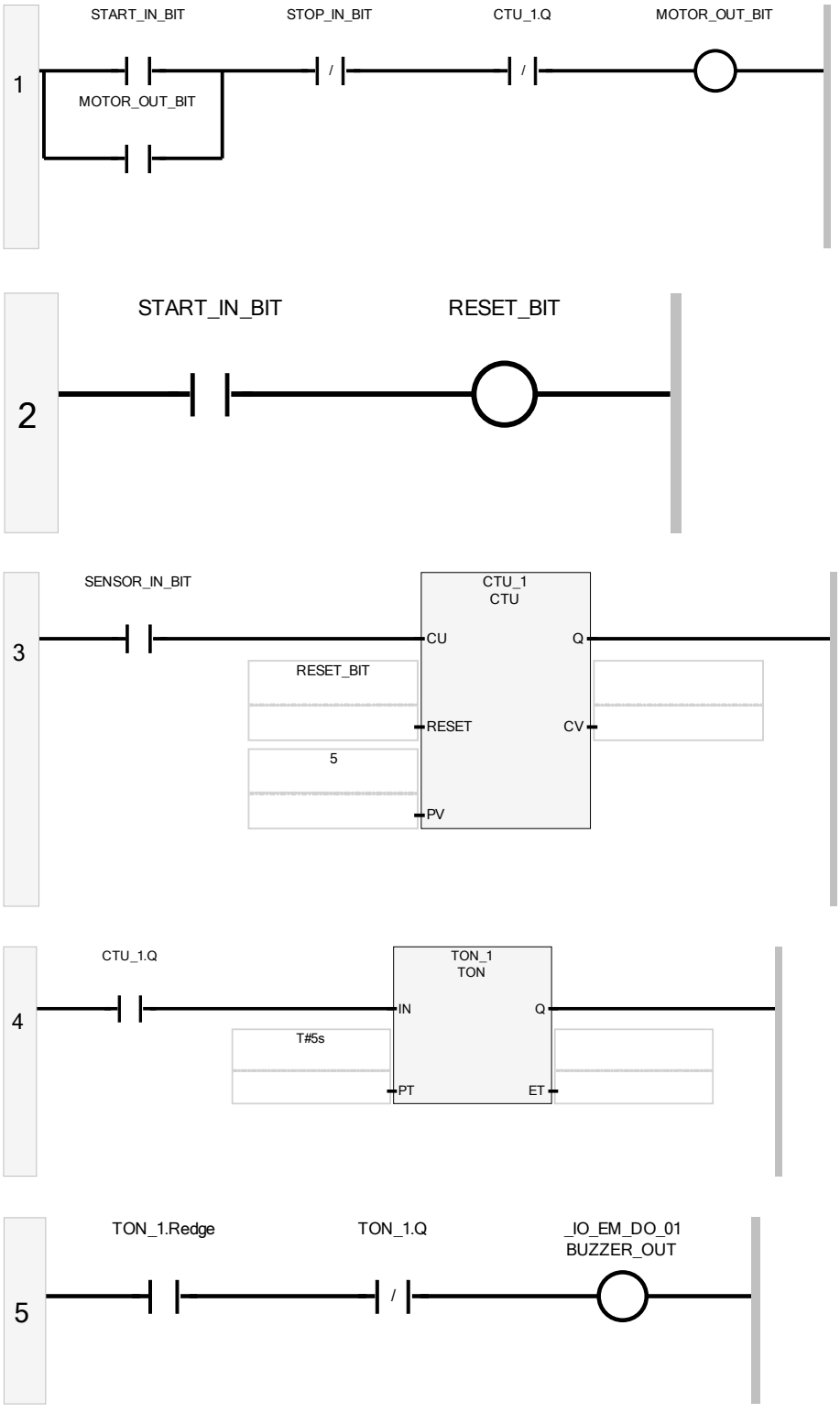



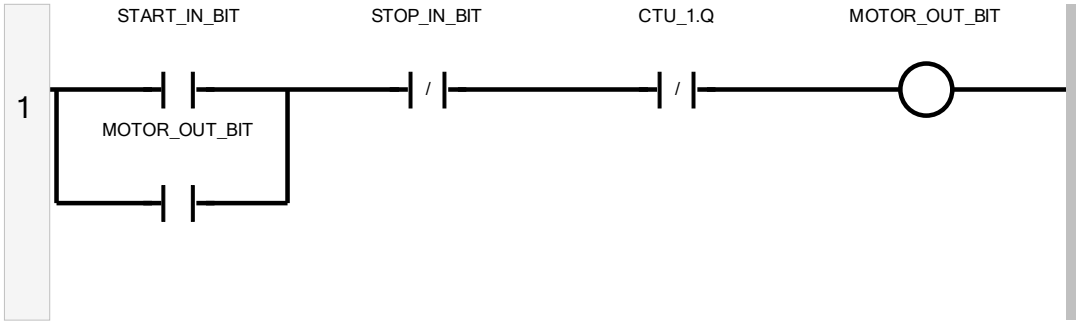



## ➢ PLC Ladder diagram: Conveyor Belt

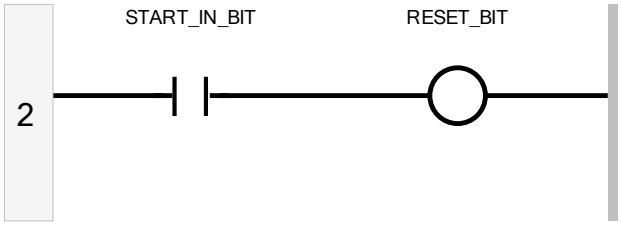


### 6.3.1.6 PLC Ladder diagram Description:

- **Rung1 Diagram:** Conveyor starts rotating in one direction when Start PB Pressed. Conveyor Stops when Stop PB Pressed or Counter reaches Preset Value.

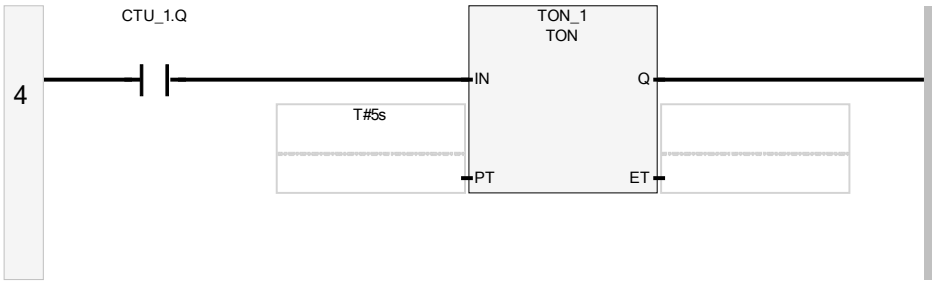



- **Rung2 Diagram:** When start PB pressed that enables counter reset.

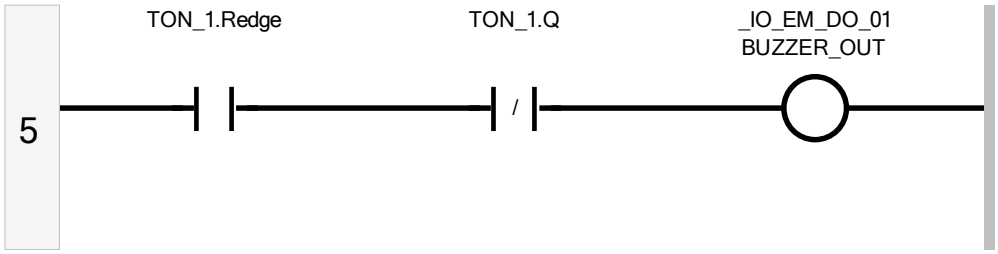



- **Rung3 Diagram:** When each time object detected by sensor counter value added by one this continues till CV=PV. When CV=PV Q becomes high.

- **Rung4 Diagram:** On timer runs for 5 seconds after counter output Q=1.




- **Rung5 Diagram:** Buzzer ON in between raising edge of timer start and until Timer output becomes Q=1. (i.e 5 Seconds)

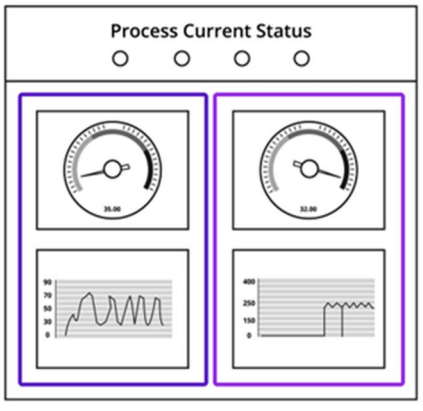


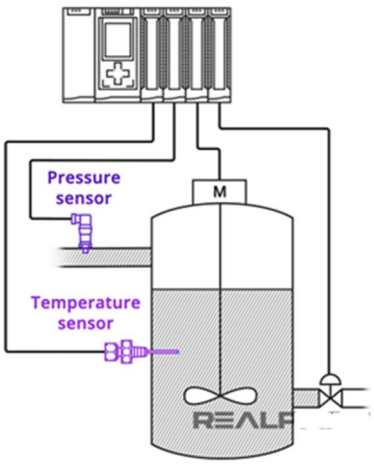

### 6.3.2.1 Sensors- Basics

What is a sensor?

A sensor is a device that senses something.

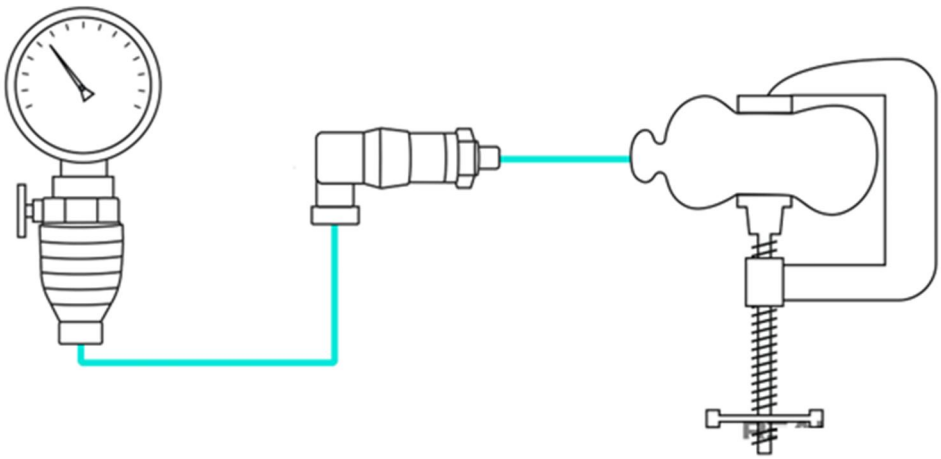
- Today we have sensors that can see, feel, hear, smell, and even taste.
- Without sensors, our home and work lives would be quite difficult.
- "Sensors" have now become crucial to improve productivity.
- There is a wide variety of sensors, each has its strengths and weaknesses.
- For example, as you drive to work, the traffic lights at an intersection are controlled by sensors embedded in the road. These sensors detect your arrival at the intersection.
- As you approach the grocery store, the door automatically opens because of a sensor.
- In your plant, the batch process temperature and pressure are displayed and controlled as a result of output from Sensors.



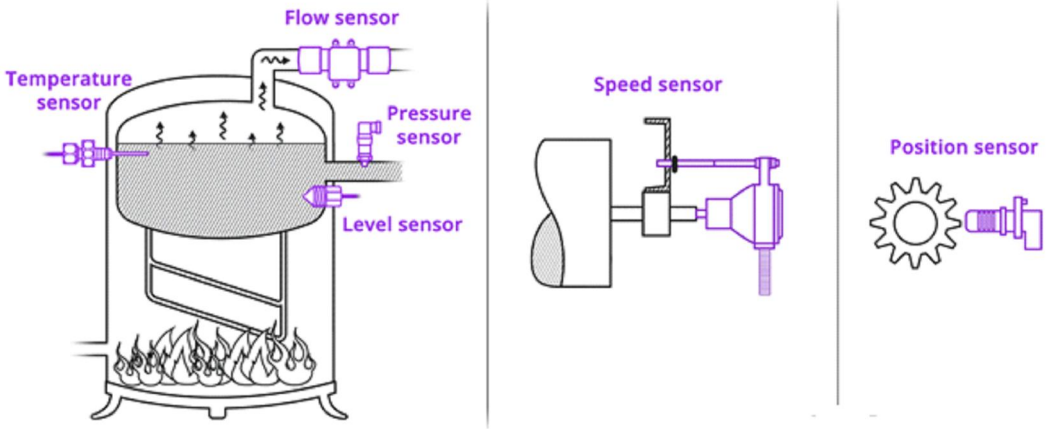
## Industrial sensors

In the world of instrumentation and process control, we define a Sensor as a device that detects changes in physical, electrical, or chemical properties and produces an electrical output in response to that change



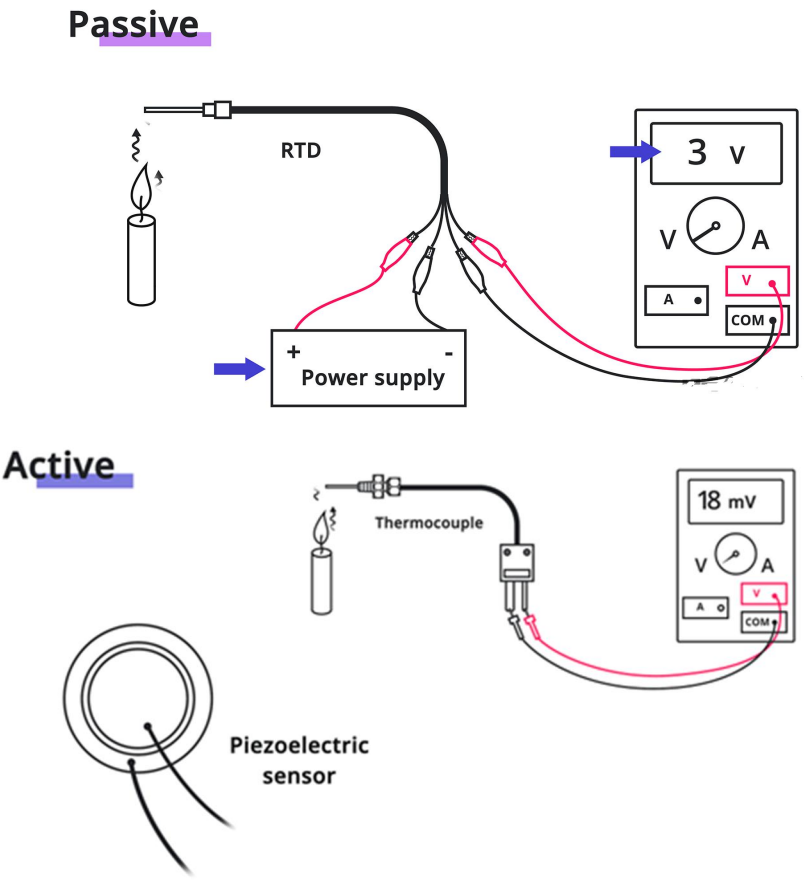
### 6.3.2.2 Types of sensors

- What are the typical physical properties that sensors are detecting? Let's name a few… Level, Temperature, Flow, Pressure, Speed, and Position.



## Classification of sensors

- From a process control perspective, we can classify sensors as either Passive or Active.
- **Passive sensors**
- A Passive Sensor requires an external source of power to operate while an Active Sensor does not. Ex: Resistance Temperature Detector (RTD)
- Active sensors
- A Thermocouple is an Active Sensor as it does not require any external power supply to operate.



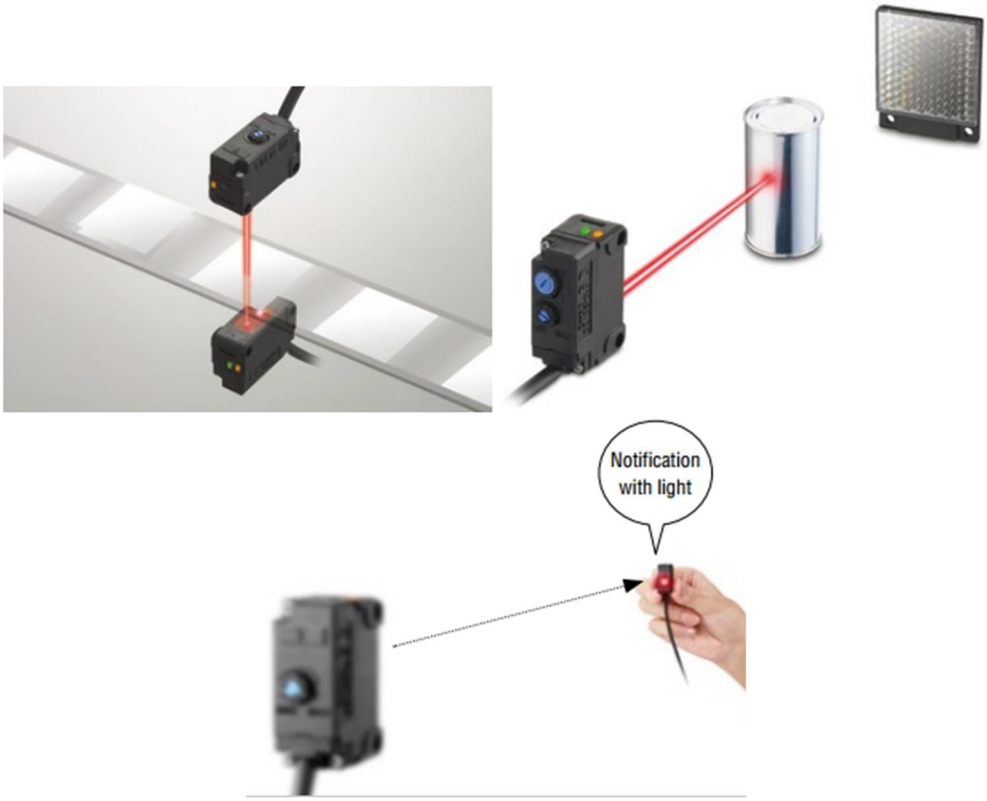

## Types of sensors: Based on Detection method

- Photoelectric Sensors - Detection based on “light”
  - Photoelectric Sensors
  - Color sensors
- Inductive Proximity Sensors - Detection based on “eddy current”

- Contact Sensors - Detection based on “contact”
- Ultrasonic Sensors - Detection based on “ultrasonic”
- Vision sensors - Detection based on “images”

### 6.3.2.2 Types of sensors: Photoelectric Sensors Detection based on “light”

- A photoelectric sensor emits a light beam (visible or infrared) from its light-emitting element.
- A reflective-type photoelectric sensor is used to detect the light beam reflected from the target.
- A thrubeam type sensor is used to measure the change in light quantity caused by the target crossing the optical axis.

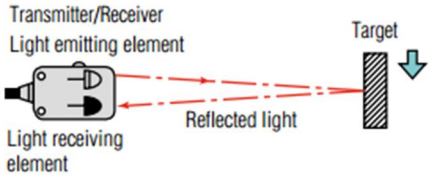



### Types of sensors: Photoelectric Sensors Detection based on “light”: Principle and major types

- A beam of light is emitted from the light emitting element and is received by the light receiving element.

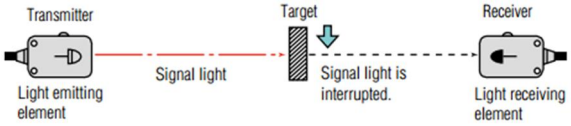
**Reflective model**

Both the light emitting and light receiving elements are contained in a single housing. The sensor receives the light reflected from the target.



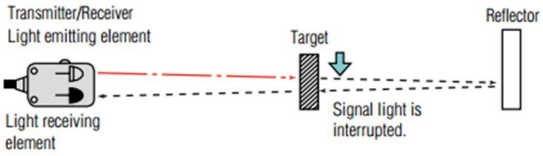

**Thrubeam model**

The transmitter and receiver are separated. When the target is between the transmitter and receiver, the light is interrupted.




**Retro-reflective model**

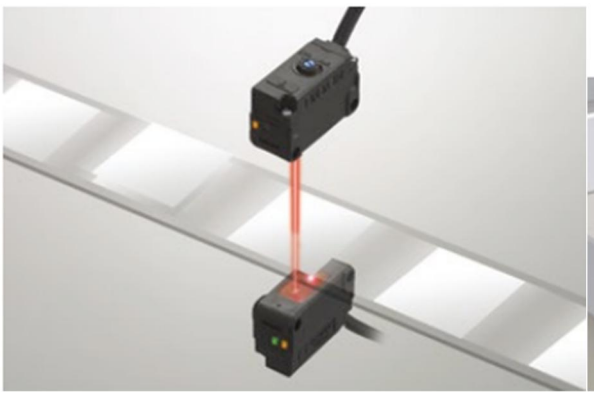
Both the light emitting and light receiving elements are contained in same housing. The light from the emitting element hits the reflector and returns to the light receiving element. When a target is present, the light is interrupted.

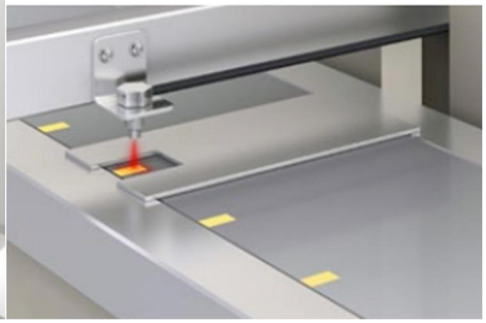


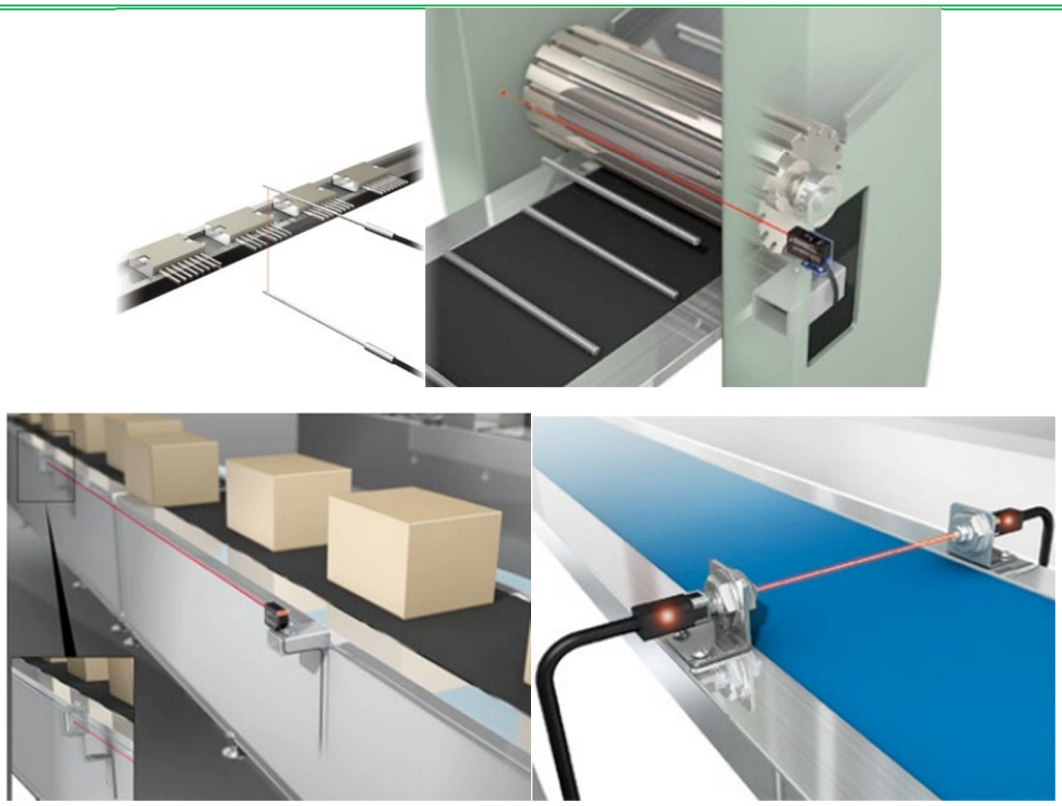

- **Types of sensors: Photoelectric Sensors**

  **Detection based on "light": Types**

  Photoelectric sensors
- Fibreoptic sensors
- Laser sensors
  - "Received light" recognition type
  - "Position" recognition type
  - Camera with built-in laser sensor
- **Color sensors**







### 6.3.2.3 Types of sensors: Color sensors

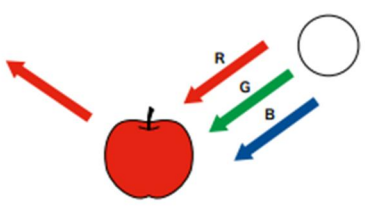
**Light-based Detection: Colour sensors**

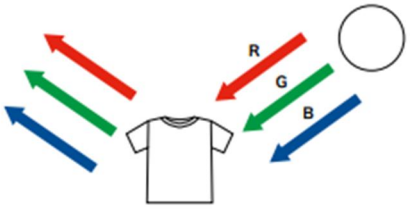
- A colour sensor is a type of "photoelectric sensor" which emits light from a transmitter, and then detects the light reflected back from the detection object with a receiver.
- A colour sensor can detect the received light intensity for red, blue and green respectively, making it possible to determine the colour of the target object.
- There are two types of colour sensors.
  - One illuminates the object with broad wavelength light and differentiates the three types of colours in the receiver.
  - The other type illuminates the object with the three types of light (red, blue, and green) independently.
- In both scenarios, the received light intensity of red, blue and green are detected, and the ratio of light received is calculated.

**Types of sensors: Color sensors**

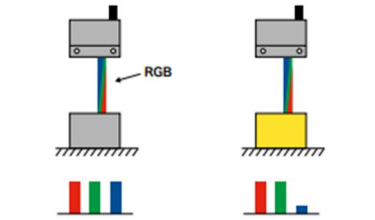
**Light-based Detection: Working principle Colour sensors**

- If light containing the red, blue, and green wavelengths is shown on a red object, only red light will be reflected.
- The white circle in the diagram represents a white light source.
- For a white object, all three colours of red, blue, and green are reflected.
- The white circle in the diagram represents a white light source.
- The ratio of the red, green, and blue reflections vary according to the colour of the object
- By calculating the ratio of the intensity of the red, green, and blue light received, it is possible to distinguish differences in the colour or appearance of the object.




| Object colour | Reflected light | | |
|---|---|---|---|
| | Red | Green | Blue |
| Red | ✓ | | |
| Yellow | ✓ | ✓ | |
| Green | | ✓ | |
| Blue | | | ✓ |
| White | ✓ | ✓ | ✓ |
| Black | | | |

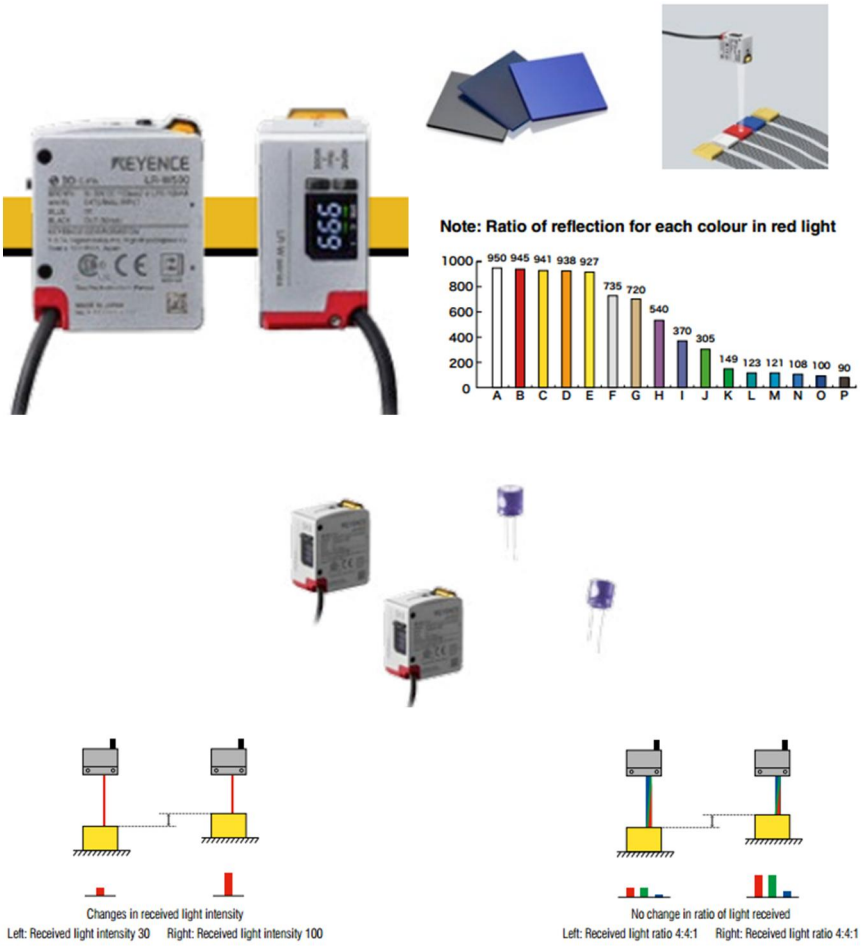



**Types of sensors: Color sensors**

**Light-based Detection: Colour sensors : Features**

- **Can stably detect differences in colour and appearance**
  - Since the light source is not just red, but includes the red, green, and blue wavelengths, and the ratio between each of these lights can be calculated, it is possible to differentiate the appearance and colour of target pieces.

- **Stable detection, even when distance changes**
  - With a conventional photoelectric sensor, when the distance to the target object changes, the received light intensity also changes.
  - On the other hand, with a colour sensor, there is no change in colour identification even when the distance to the target changes.
  - As a result, the target's colour can be stably differentiated even if the distance changes or the target is tilted.




### 6.3.2.4 Types of sensors: Ultrasonic sensors

**What is ultrasonic?**

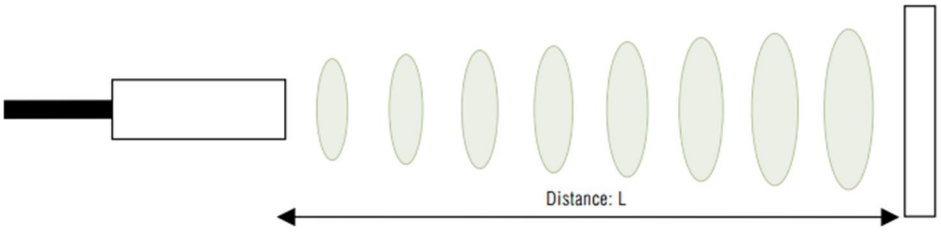
- "Ultrasonic" generally refers to a "high pitch sound that is inaudible to humans."
- Sound is expressed by a unit called frequency (Hz). The greater the frequency, the higher the pitch of sound becomes.
- The audible range for humans is said to be between about 20 Hz and 20 kHz.
- In other words, ultrasonic waves have a frequency of20 kHz or greater.

- **Familiar examples of devices using ultrasonic waves**
- In our ordinary life, the following ultrasonic sensors are used:
  - Fish detector (used for fishery or bass fishing)
  - Active sonar in a submarine (used for finding enemy submarines or battle ships)
  - Back sonar for cars (for detecting obstacles during backing a car to prevent single-car accident)

**Types of sensors: Ultrasonic sensors**

**Detection based on "ultrasonic" : Detection principle**

- As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves.
- The sensor head emits an ultrasonic wave and receives the wave reflected back from the target.
- Ultrasonic sensors measure the distance to the target by measuring the time between the emission and reception.




- An optical sensor has a transmitter and receiver, whereas an ultrasonic sensor uses a single ultrasonic element for both emission and reception.
- In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately. This enables miniaturisation of the sensor head.

**Types of sensors: Ultrasonic sensors**

**Detection based on "ultrasonic" : Distance calculation**

- The distance can be calculated with the following formula:
- Distance $L = 1/2 \times T \times C$
  - where L is the distance,
  - T is the time between the emission and reception,
  - and C is the sonic speed.

- (The value is multiplied by 1/2 because T is the time for go-and-return distance.)

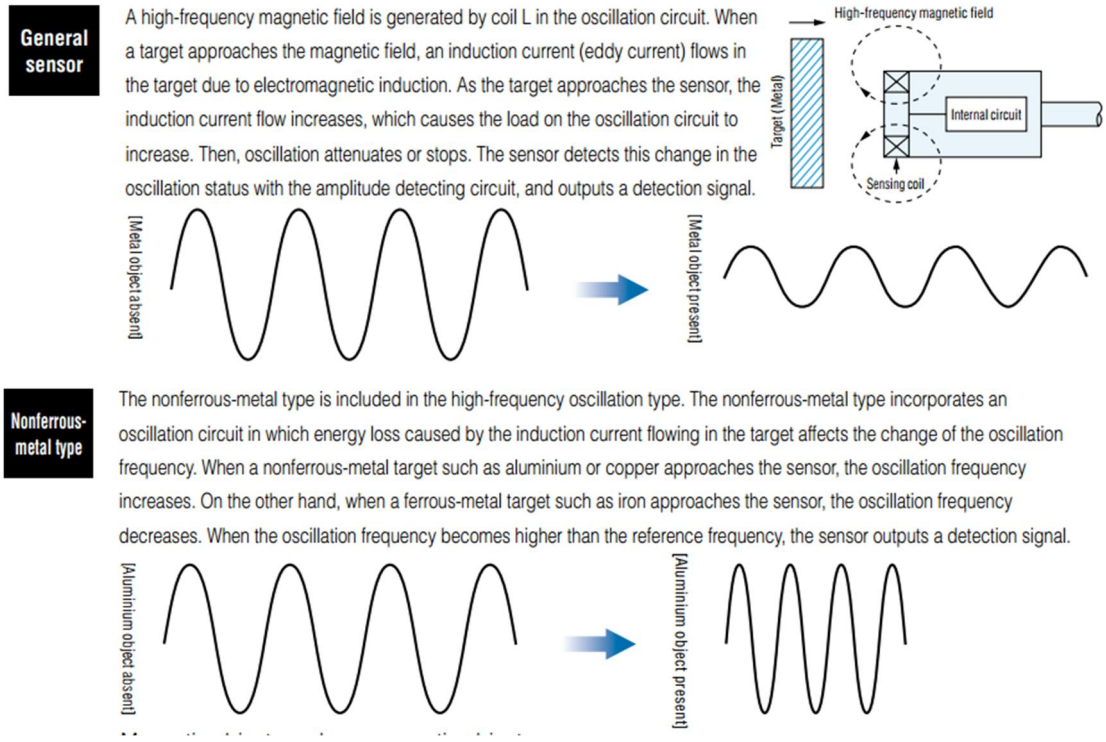
- Comparison between optical sensors (reflective model) and ultrasonic sensors - Typical sensors used for distance measurement are optical sensors.

| Item | Optical (reflective model) * | Ultrasonic |
|---|---|---|
| Detectable target | Detection is affected by target materials/colours | Detection is unaffected by target materials/colours |
| Detecting distance | 1000 mm max. | 10 m max. |
| Accuracy | High | Low |
| Response speed | Fast | Slow |
| Dust/water | Affected | Unaffected |
| Measuring range | Small | Large |

## 6.3.2.5 Types of sensors: Inductive Proximity sensors Detection based on "eddy current" : Major Types

- A proximity sensor can detect metal targets approaching the sensor, without physical contact with the target.
- Proximity sensors are roughly classified into the following three types according to the operating principle:
  - the high-frequency oscillation type using electromagnetic induction,
  - the magnetic type using a magnet,
  - the capacitance type using the change in capacitance.

## Types of sensors: Inductive Proximity sensors
## Detection based on “eddy current” : Detection principle

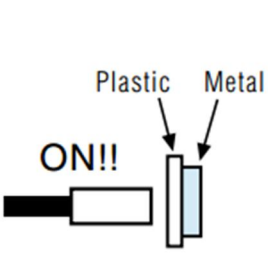



## Types of sensors: Inductive Proximity sensors
## Detection based on “eddy current” : Features

- Detecting metal only.
  - Inductive proximity sensors can only detect metal targets. They do not detect non-metal targets such as plastic, wood, paper, and ceramic
- Excellent environmental resistance
  - Proximity sensors are durable

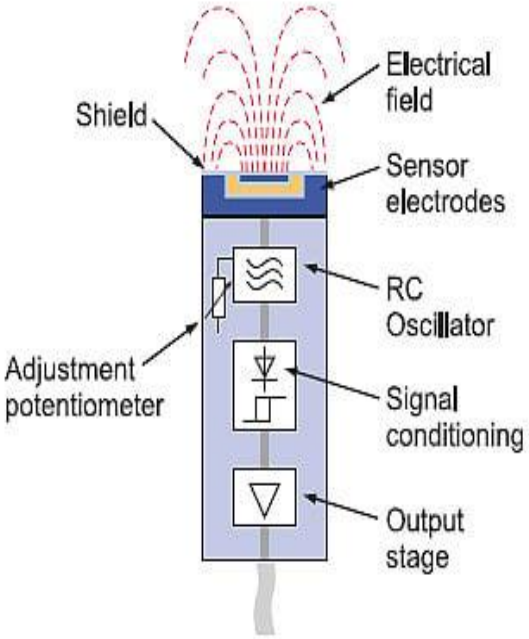
- Two-wire type proximity sensors allow simplified wiring and can be used for both NPN and PNP circuits.

- Another advantage is that their current consumption is extremely low such as 1 mA




### 6.3.2.6 Types of sensors: Capacitive Proximity sensors Detection based on "change in capacitance" :

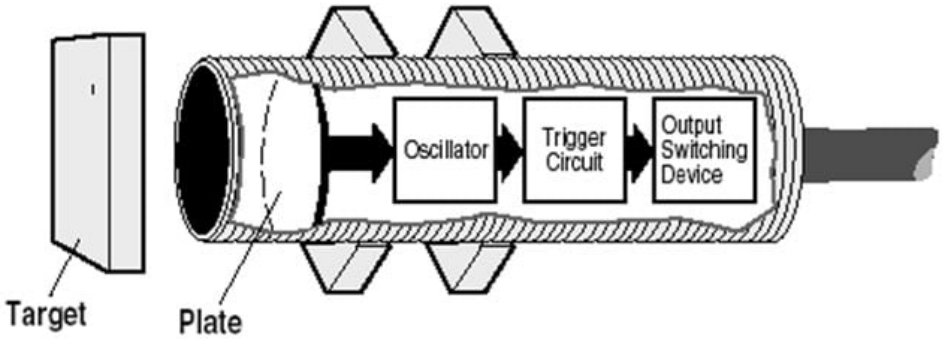
- Capacitive Proximity Sensors detect changes in the capacitance between the sensing object and the Sensor.
- As per the name, capacitive proximity sensors operate by noting a change in the capacitance read by the sensor.
- The amount of capacitance varies depending on the size and distance of the sensing object.
- An ordinary Capacitive Proximity Sensor is similar to a capacitor with two parallel plates, where the capacity of the two plates detected.




**Types of sensors: Capacitive Proximity sensors**

**Detection based on "change in capacitance" : Detection**

- The capacitive proximity sensor consist a high-frequency oscillator along with a sensing surface formed by two metal electrodes.
- When an object comes near the sensing surface, it enters the electrostatic field of the electrodes and changes the capacitance of the oscillator.
- As a result, the oscillator circuit starts oscillating and changes the output state of the sensor when it reaches certain amplitude.
- As the object moves away from the sensor, the oscillator's amplitude decreases, switching the sensor back to its initial state.
- A typical sensing range for capacitive proximity sensors is from a few millimeters up to about 1 inch. (or 25 mm), and some sensors have an extended range up to 2 inch.




**Types of sensors: Capacitive Proximity sensors Detection based on "change in capacitance" : Features**

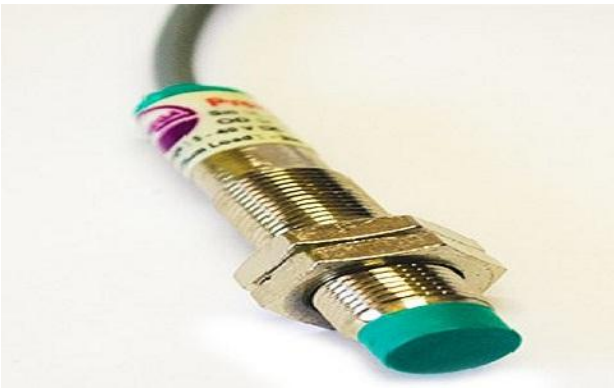
- The ability to detect nonmetallic objects.
- The ability to detect small lightweight objects that cannot be picked up by mechanical limit switches.
- A solid-state output that does not bounce its contact signal.
- A high switching rate that provides quick reaction in object counting applications.
- The ability to detect liquid targets through certain barriers.
- A long operational lifespan.

### 6.3.2.7 Types of sensors: Magnetic sensors Detection based on "change in magnetic field" :

- The measurement of proximity, position, as well displacement of objects is very important in several applications which include the position of the valve, detection of level, safety, machine control, and process control.
- There are many manufacturing companies offering magnetic sensors that are used in many applications where high dependability & cost-optimized solutions are needed.
- Magnetic proximity sensors are used for non-contact object detection beyond the normal limits of inductive sensors. Used with a separate damping magnet, they offer very long sensing ranges in a small package and can detect magnets through walls of non-ferrous metal, stainless steel, aluminum, plastic or wood.
- Magnetic sensor definition is a sensor which is used to notice disturbances as well as changes within a magnetic field such as strength, direction, and flux.
- These sensors are separated into two groups.
    - The first one is used to calculate the total magnetic field,
    - whereas the second one is used to calculate vector components of the field.

**Types of sensors: Magnetic sensors Detection based on "change in magnetic field" :Working Principle**

- The magnetic sensor comprises a chip with a magnetoresistive component which is used to detect a magnetic vector & a magnet intended for magnetic vector biasing which can be detected by the magnetoresistive component.
- The chip which is used in the sensor can be used for sensing the change within the magnetic vector. This vector notices the behavior of a magnetic body depending on a change of resistance value of the magnetoresistive component.



**Types of sensors: Magnetic sensors**
**Detection based on "change in magnetic field" :Types**

- The classification of Magnetic sensors can be done based on detecting the dissimilarity of magnetic sensors like a low field, earth field, and bias magnetic field sensors.
- **Low Field Sensors**
  - These sensors are used to detect extremely low values of the magnetic fields like 1uG (1 Gauss is equal to 10-4 Tesla. The best examples of this are Nuclear procession, Fiber optic, and SQUID. The applications of low field sensors mainly include in nuclear as well as medical fields.
- **Earth Field Sensors**
  - The range of magnetic for this type of sensor ranges from 1uG to 10 G. This sensor uses the magnetic field of the earth in several applications like the vehicle as well as navigation detection.

- **Bias Magnet Field Sensors**
- These sensors are used to sense the enormous magnetic fields above 10 Gauss. Most of the sensors used in industries use permanent magnets like a source of the noticed magnetic field. These magnets will bias otherwise magnetize the ferromagnetic objects which are close to the sensor. The sensors which are in this type mainly include hall devices, GMR sensors, and reed switches.

## Reference:


1) https://www.sanfoundry.com/plc-program-counting-parts-conveyor/
2) https://realpars.com/types-of-sensors/
3) https://robu.in/capacitive-proximity-sensor-working-principle/
4) https://www.elprocus.com/magnetic-sensor-working-and-its-applications/
5) https://instrumentationtools.com/plc-program-conveyor-motor/