# UNIT-3

# SENSORS AND MACHINE VISION

Requirements of a sensor, Principles and Applications of the following types of sensors- Position sensors – Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, pneumatic Position Sensors, Range Sensors Triangulations Principles, Structured Lighting Approach, Time of Flight, Range Finders, Laser Range Meters, Touch Sensors ,binary Sensors, Analog Sensors, Wrist Sensors, Compliance Sensors, Slip Sensors, Camera, Frame Grabber, Sensing and Digitizing Image Data- Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis-Data Reduction, Segmentation, Feature Extraction, Object Recognition, Other Algorithms, Applications- Inspection, Identification, Visual Serving and Navigation.

# Introduction to sensor

- Sensors are the sensory systems of a robot.
- Like Human have five senses
- 1.Touch 2.Sight 3.Sound 4.Smell 5.Taste
- Robot also have senses like Measure environment data touch, sound, strain, rotation,magnetism,smell,tempertaure, inclination, pressure
- Sensor is an electronic device that transfers a physical phenomenon ( Temperature, Pressure,Humidity,etc) into an electrical signals.
- Definition of Sensors:
- A sensor is a device,module,machine or sub system whose purpose is to detect events or changes in its environments an send the information to other electronics.

# Introduction to sensor

- Sensor is device that receives and responds to a signal or stimulus. A device that detects and measure a signal. Acquires information from the real world.

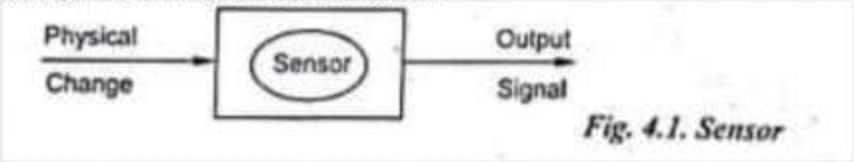


*Fig. 4.1. Sensor*

- Robotic Sensors mainly classified:

1.Position Sensor
2.Proximity Sensor
3.Velocity sensor
4.Range Sensor

- Uses of Sensors:

- Safety Monitoring
- Inter lock in work cell control
- Part inspection for quality control
- Determining positions and related information about object in the robot.

# Requirements of a sensor

- Localization.
- Obstacle Detection.
- Internal information.
- Sensors play the vital role in the field.
- Safety monitoring.
- Work part inspection and Data Collection.
- To avoiding the physical injuries and other damages caused to the human workers.
- To determine the quality features of the work part automatically.
- Data collection of the objects in robot work cell.
- Without the uses of sensors, there would be no automation.

# Classification of Sensors

1. **Based on the contact sensor**
   1. Slip sensor
   2. Force sensor
   3. Touch sensor
   4. Tactile sensor
   5. Proximity sensor (or) Displacement sensor
2. **Based on the Non contact sensor**
   1. Visual sensor
   2. Optical sensor
   3. Magnetic sensor
   4. Inductive sensor
   5. Resistive sensor
   6. Capacitive sensor
   7. Ultrasound sensor
   8. Air pressure sensor
3. **Based on the Active sensor**
   (*i*) Thermistor
   (*ii*) Resistive strain gauge
4. **Based on the Passive sensor**
   (*i*) Photodiode
   (*ii*) Piezo electric sensor
5. **Based on the Internal sensor**
   (*i*) Position sensor
   (*ii*) Velocity sensor
   (*iii*) Torque sensor
   (*iv*) Acceleration sensor
   (*v*) Displacement sensor
6. **Based on the External sensor**
   (*i*) Tactile sensor
   (*ii*) Force sensor

# Classification of Sensors

(iii) Proximity sensor
(iv) Range sensor
(v) Vision sensor

7. **Based on the Analog sensor**
8. **Based on the Digital sensor**
   1. Motion
   2. Intensity
   3. Temperature
   4. Measurement of displacement
9. **Based on the Position sensor**
   (i) Potentiometer position sensor (or) Resistance based.
   (ii) Capacitive position sensor
   (iii) Linear variable differential transformer (LVDT)
   (iv) Magnetostictive linear position sensor.
   (v) Eddy current based position sensor
   (vi) Hall effect based magnetic position sensor
   (vii) Optical position sensor
10. **Based on the Proximity sensor**
    (i) Inductive proximity sensor
    (ii) Capacitive proximity sensor
    (iii) Photo electric proximity sensor
    (iv) Hall effect sensor.
    (v) Optical proximity sensor
    (vi) Eddy current proximity sensor
    (vii) Magnetic proximity sensor
11. **Based on Velocity sensor**
    (i) Piezo electric sensor
12. **Based on Range sensor**
    (i) Triangulation
    (ii) Structural lighting
    (iii) Time of flight
13. **Based on Light based laser sensor**
    (i) Light based laser range finder
    (ii) Laser range meter
14. **Based on Ultrasonic sensor**
    (i) Ultrasonic range finder
    (ii) Ultrasonic range sensor
15. **Based on Tactile sensor**
    (i) Touch sensor
    (ii) Force sensor
    (iii) Slip sensor

# Types of sensors

There are different types of sensors are given below:

1.Active Sensor:

- Required additional power called excitation signal.
- Sensor modify excitation signal to provide output.
- Example: Thermistor, Resistive Strain Gauge

2.Passive Sensor:

- Directly generate an electrical signal in response to an external stimulation.
- No need Additional Energy
- Example: Photo Diode, Photo electric sensor

# Types of sensors

3.External Sensor:

- Control the operation of the robot with of the piece of equipment.
- External to the robot itself.
- Example:Barrier,Distance,Sight Light

4.Internal Sensor:

- Detect the required task.
- Changes in variable Manipulator.
- Example:Time,Direction,Wheel Rotation

5.Contact Sensors

6.Non Contact Sensor

7.Analog Sensor

8.Digital Sensor

9.Robot Sensor

## Transducer:

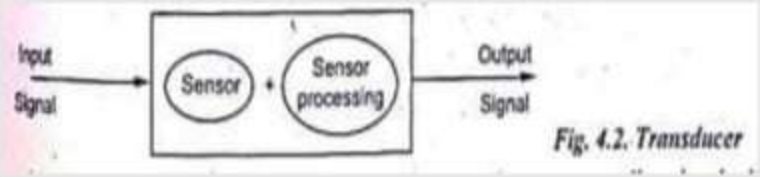


Fig. 4.2. Transducer

- A device that converts a primary form of energy into corresponding signal with a different energy form.
- Different form of energy such as mechanical,Thermal,Electro-Magnetic and Optical

*Table 4.1. Differentiate between Sensor and Transducer*

| S.No | Parameter | Sensor | Transducer |
|---|---|---|---|
| 1. | Mode | Input device | Output device |
| 2. | Define | A sensor is a device which detects one form of energy and converts the data to electrical energy. | Transducer is a device which converts one form of energy into another. So sensors are in fact a type of transducer. |
| 3. | Function | A sensor is a device which detects a physical quantity and produces on electrical signal. Signal based on the strength of the quantity measured. | A transducer is a device which converts one form of energy into another form. |
| 4. | Sensing element | Sensing element itself | Sensing element plus any associated circuitry. |
| 5. | Feedback | A sensor merely measured a quantity and cannot itself give feedback to the system. | A transducer can convert between any forms of energy. They can be used to provide feedback to the system. |
| 6. | Temperature | Thermocouple, Thermistor, Thermostat | Heater and Fan |
| 7. | Force (or) pressure | Strain gauge, Pressure, Switch, Load cells | Lifts and Jacks, Electro magnet, Vibration |
| 8. | Position sensor | Potentiometer, Encoders, LVDT | Motor, Solenoid, Panel meters |

# Performance or Characteristics or Desirable features of Sensor

- Accuracy:

  Difference between the Theoretical and actual Position.

- Precision:

  Closely Measured Value cluster around a best estimate of the real value.

- Repeatability

  = [(Max Value – Min Value)/ Full range]*100

- Resolution:

  Measured value Minimum Difference between Two values

- **Sensitivity:**

  Ratio of output changes to input change.

- **Range:**

  Measurement limit is minimum and maximum

- **Calibration:**

  Sensor steps into ensure efficiency and more accurate measurement.

- **Span:**

$$\text{Span} = \text{Maximum value of input} - \text{Minimum value of input}$$

- **Error:**

$$\text{Error} = \text{Measurement value} - \text{True value}$$

# Position Sensors

- A **position sensor** is a sensor that facilitates measurement of mechanical position. A position sensor may indicate absolute position (location) or relative position (displacement), in terms of linear travel, rotational angle, or three-dimensional space.
- **Example**: GPS(Global Positioning System),Satellite orbiting earth transmitting, Sonar system, Rader system, Proximity sensor.
- Advantages:

1. Compact size
2. Light weight
3. High accuracy
4. No need for tearing, bushes (or) seals.
5. Ability to sense over wide range of geometry.
6. Stability respective to environmental condition.

# Position Sensors

- Disadvantages:
  - Low Accuracy,
  - Low Repaetability,
  - Limited Frequency responses,
  - Wear due to Moving parts.
- Appilcation:
  - Drive by wire cars.
  - Medical Equipment
  - Injection molding machines.
  - Bullet trains taking round curves.

# Position Sensors

- Common types of position sensors include:.

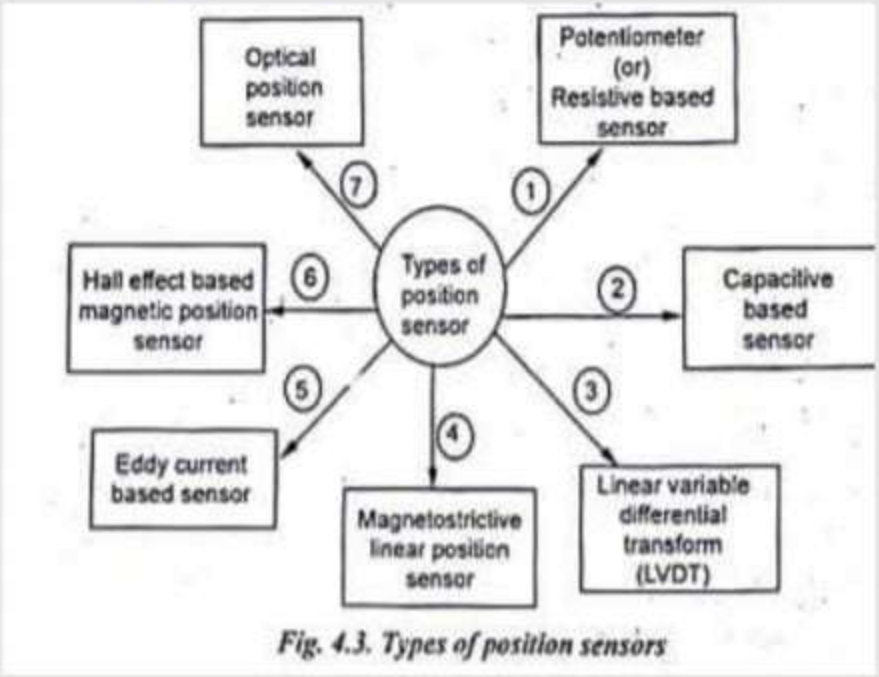



*Fig. 4.3. Types of position sensors*

# Potentiometer(POT)

- Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers.

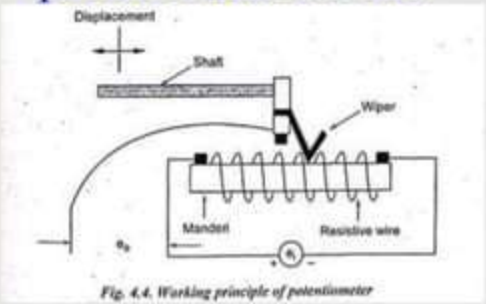


Fig. 4.4. Working principle of potentiometer

- A **potentiometer** is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a **variable resistor** or **rheostat**.

# Potentiometer(POT)

- Third terminals is used for controlling the variable resistor.
- Body of the sensor Resistive Material and wire is wound on it.
- Working Principle:
- S-Switch used for connecting or disconnecting the galvanometer.
- Slide wire-supply the working current.
- Unknown voltage depends on Sliding position.

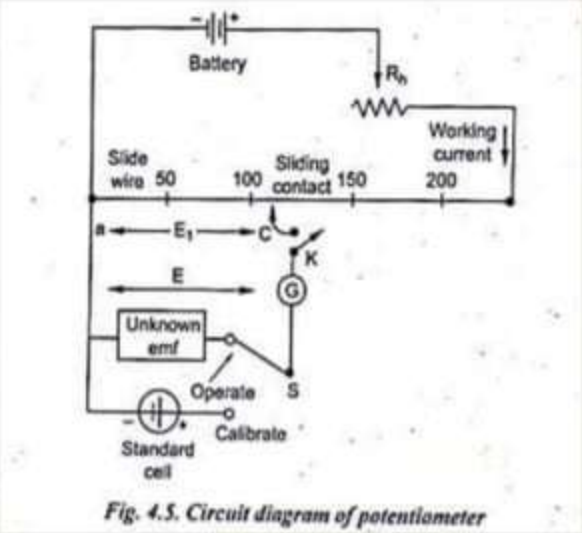



*Fig. 4.5. Circuit diagram of potentiometer*

# Potentiometer(POT)

- Working Principle:
- Zero or Null deflection shows that the potential of the unknown source E. Voltage drops $E_1$
- Unknown voltage is evaluated by knowing the voltage drop across 'ac' portion of the sliding wire.
- Resistance moves across the entire length.
- Important Parameters:

1.Dither 2.Humidity

3.Shock and Vibration 4.Operating Temperature.

5.Contamination and seals.

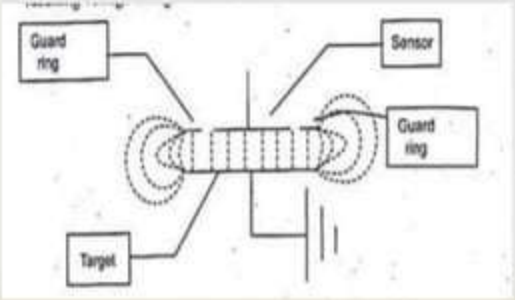
Applications:

1Volume control 2.Brightness control 3.Linear displacement

4.Rotary displacement 5.Liquid level measurement using floats

# Capacitance Based Position Sensor

**Capacitive displacement sensors** "are non-contact devices capable of high-resolution measurement of the position and/or change of position of any conductive target". They are also able to measure the thickness or density of non-conductive materials. Capacitive displacement sensors are used in a wide variety of applications including semiconductor processing, assembly of precision equipment such as disk drives, precision thickness measurements, machine tool metrology and assembly line testing.




Capacitance is an electrical property which is created by applying an electrical charge to two conductive objects with a gap between them. A simple demonstration is two parallel conductive plates of the same profile with a gap between them and a charge applied to them.

In this situation, one of the conductive plates, is the sensor, and in place of the other, is the conductive target to be measured.

The operation of the sensor for measuring thickness of non-conductive materials can be thought of as two capacitors in series, with each having a different dielectric (and dielectric constant).

# Capacitance Based Position Sensor

## Advantages:

1.Sensors uses non metallic targets.

2.Detect through container.

3.Simple construction and adjustable.

4.Cost is low.

5.Higher sensitivity

## Disadvantages:

1.High sensitivity it is affect by Environmental conditions.

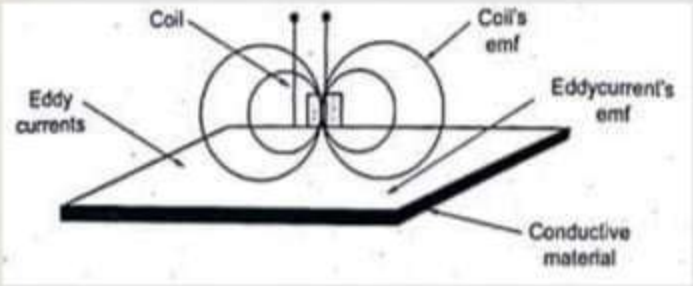
2.Hard to measurement of resistance.

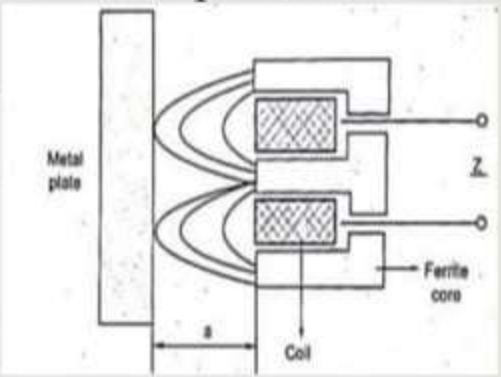
# Eddy current based position sensor

- **Eddy current sensor**s uses the principle of eddy current formation to sense displacement.
- Eddy currents are formed when a moving or changing magnetic field intersects a conductor or vice versa.
- The relative motion causes a circulating flow of electrons, or currents, within the conductor.
- These circulating eddies of current create electromagnets with magnet fields that oppose the effect of applied magnetic field.
- The stronger the applied magnetic field, or greater the electrical conductivity of the conductor, or greater the relative velocity of motion, the greater the currents developed and greater the opposing field.

# Eddy current based position sensor

- Eddy current probes senses this formation of secondary fields to find out the distance between the probe and target material.
- Primary magnetic filed gives electrical conducting materials.
- Secondary magnetic filed turn the coil impedance.



# Magnetostrictive Linear Position Sensor

- A magnetostrictive position sensor measures the distance between a position magnet and the head end of the sensing rod.
- The position magnet does not touch the sensing rod, and therefore there are no parts to wear out.
- The sensing rod is mounted along the motion axis to be measured, and the position magnet is attached to the member that will be moving.
- The head includes an electronics module, which reports the position information to a controller (or other receiving device) in the appropriate analog or digital format.
- The position magnet is a permanent magnet, often made in the shape of a ring, which travels along the sensing rod. The wave-guide is housed within the sensing rod, and is a small diameter tubing or wire made from a magnetostrictive material.

# Magnetostrictive Linear Position Sensor

- Magnetostriction is a property of ferromagnetic materials such as iron, nickel, cobalt and their alloys to expand or contract when placed in magnetic field.
- Initially when these ferromagnetic materials are not magnetized the magnetic domains of the ferromagnetic material are randomly distributed.

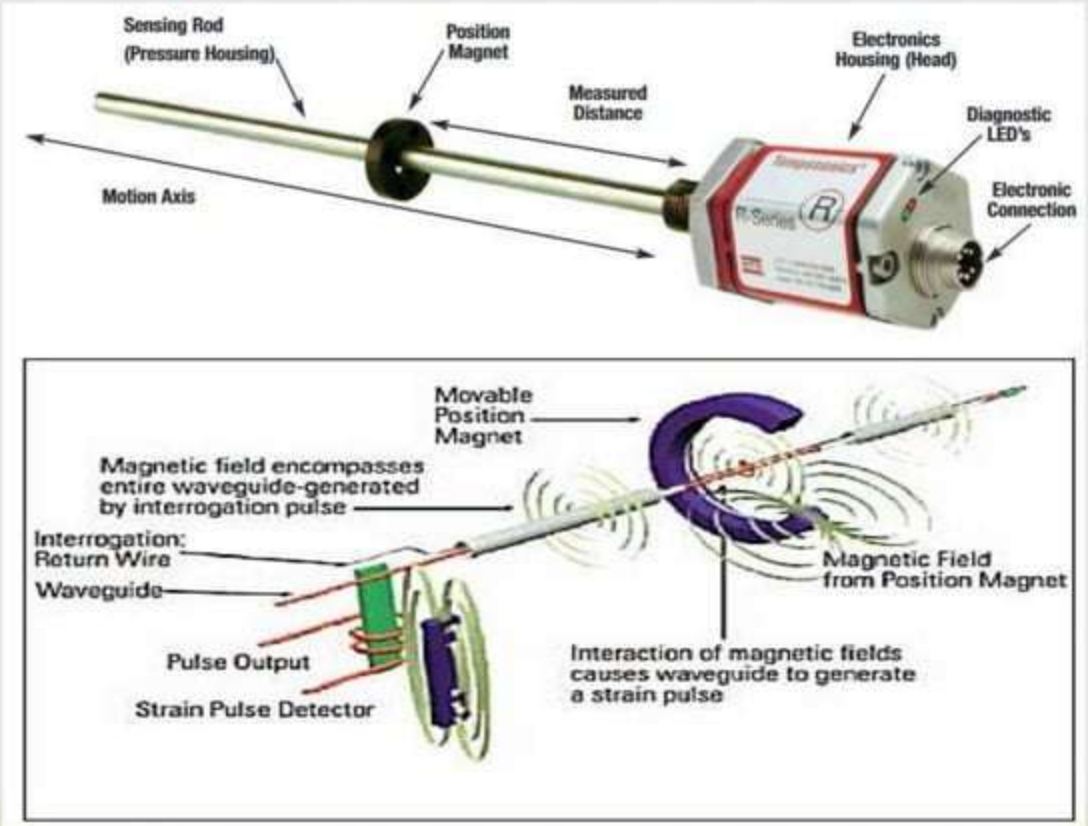
- A magnetostrictive sensor is used to measure linear position.
- It basically senses the position of the permanent magnet (position magnet) to determine the distance between the permanent magnet and the sensor head.
- When the magnetic field is applied, the poles of the magnetic domains align themselves along the gradient of the flux lines of this field.

# Magnetostrictive Linear Position Sensor

## Working Principle:

- The axial magnetic field is provided by a position magnet. The position magnet is attached to the machine tool, hydraulic cylinder, or whatever is being measured.
- The location of the position magnet is determined by first applying a current pulse to the waveguide. At the same time, a timer is started.
- The sonic wave travels along the waveguide until it is detected by the pickup.
- This stops the timer. The elapsed time indicated by the timer then represents the distance between the position magnet and the pickup.

# Magnetostrictive Linear Position Sensor

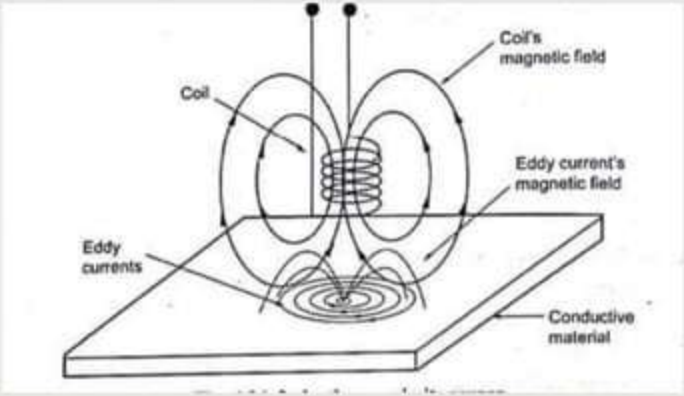


# Hall effect based magnetic position sensor

- A **Hall effect sensor** is a device that is used to measure the magnitude of a magnetic field. Its output voltage is directly proportional to the magnetic field strength through it.
- Hall effect sensors are used for proximity sensing, positioning, speed detection, and current sensing applications.
- Hall sensor is combined with threshold detection so that it acts as and is called a switch.
- Hall sensors are commonly used to time the speed of wheels and shafts, such as for internal combustion engine ignition timing, tachometers and anti-lock braking systems.
- They are used in brushless DC electric motors to detect the position of the permanent magnet. In the pictured wheel with two equally spaced magnets, the voltage from the sensor will peak twice for each revolution.

# Hall effect based magnetic position sensor

- Flux lines exert a force on the semiconductor material.
- Electrons holes to Either side of the semi conductor.
- The sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced



# Hall effect based magnetic position sensor

Advantages:

1.High Speed 2.Robust

3.Maintenance free. 4.High Reliable

Disadvantage:

External magnetic fields may affect values.

Application:

1.Marine

2.Mobile vehicle

3.Agricultural machinery

4.Automation equipment.

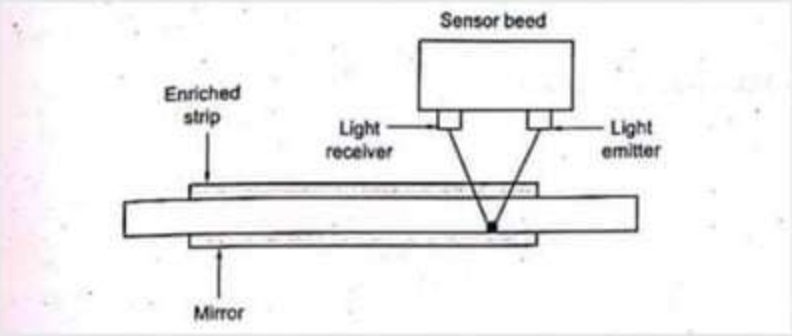
5.Process and Packaging machines.

# Optical Position Sensor

- Sensors converts light rays into an electrical signal.

It Have 2 Types:

- First Type light is transmitted from one end and received at other end.
- Second type transmitted light is reflected from the object.



- Optical triangulation position sensors use reflected waves to pinpoint position and displacement.
- They are noncontact height or range measurement devices.
- These sensors use an optical transmitter to project light on the target. The reflection of that light is focused via an optical lens on a light sensitive receiver.

- The distance is calculated from a reference point by determining where the reflected light falls on a detector.
- If the target changes position, the reflected light changes as well.
- Conditioning electronics provide an output signal proportional to target position.

# Optical Position Sensor

- Optical Encoder consists of a glass or plastic disc rotates between a light source(LED)and light receiver(Photo detector)

Advantages:

1.Fast 2.Sensitive 3.Physical flexible

Disadvantages:

1.Bulky 2.Chirping 3.More power Consumption

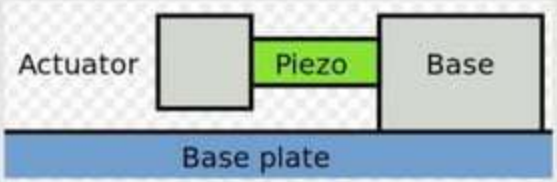
Application:

1.Position Measurement

2.Distance Measurement

# Piezo Electric Sensor

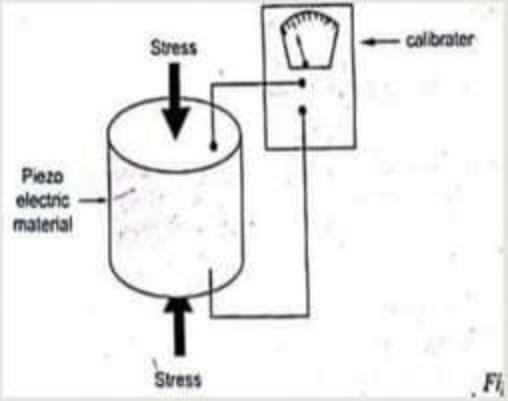
- A sensor which works on the principle of piezo electricity is known as piezo electric sensor.
- Sensor is used to measure the change of pressure, force, temperature, strain and acceleration. They are converted into electrical charge.
- The principle of operation of a piezoelectric sensor is that a physical dimension, transformed into a force, acts on two opposing faces of the sensing element.
- Depending on the design of a sensor, different "modes" to load the piezoelectric element can be used: longitudinal, transversal and shear.
- Detection of pressure variations in the form of sound is the most common sensor application



# Piezo Electric Sensor

- Commonly measure physical quantities by the sensor are acceleration and pressure.
- Pressure sensor is a thin membrance is placed on massive base transfer.
- Membrance gets loaded and starts generating electrical voltage.
- Produced voltage is proportional to the amount of pressure applied.

  - When motion is applied seismic mass load the piezo electric material according to Newton's Second law of motion.
  - Piezo electric material generates charge used for calibration of motion.



# Piezo Electric Sensor

Specification:

1.Range 2.Reliability 3.Sensitivity

Advantages:

1.Good Frequency 2.Pollution free 3.Cost is less

4.Replacement of this equipment is very easy.

Disadvantages:

1.High temperature sensitivity.

2.Dynamic measurement only

3.Crystal is prone to cracking gets over stressed.

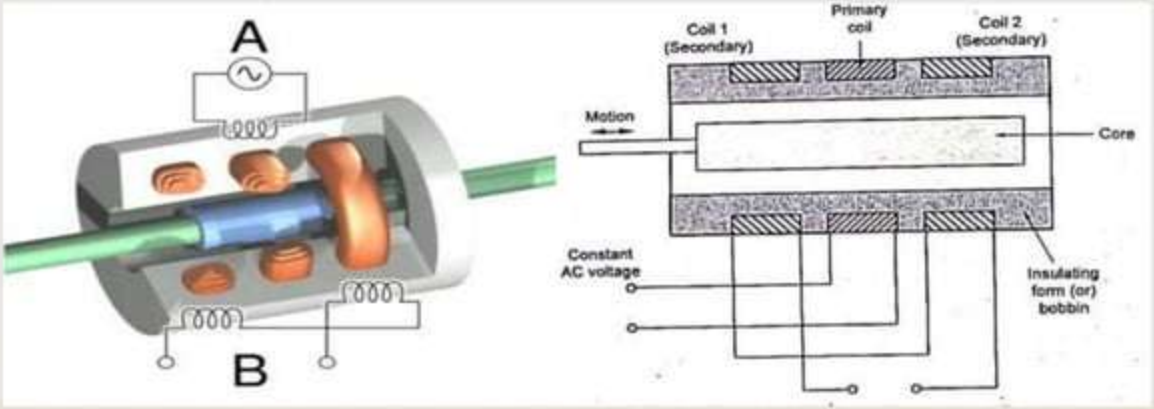
Application:

1.Accelerometer 2.Record player 3.S.I Engines

4.Sound imaging 5.Microphones

# Linear Variable Differential Transformer (LVDT)

The linear variable differential transformer (LVDT) (also called linear variable displacement transformer, linear variable displacement transducer, or simply differential transformer) is a type of electrical transformer used for measuring linear displacement (position). A counterpart to this device that is used for measuring rotary displacement is called a rotary variable differential transformer (RVDT).



## Linear Variable Differential Transformer (LVDT)

- The linear variable differential transformer has three solenoidal coils placed end-to-end around a tube.
- The center coil is the primary, and the two outer coils are the top and bottom secondaries.
- A cylindrical ferromagnetic core, attached to the object whose position is to be measured, slides along the axis of the tube.
- An alternating current drives the primary and causes a voltage to be induced in each secondary proportional to the length of the core linking to the secondary.
- The frequency is usually in the range 1 to 10 kHz.
- LVDTs are commonly used for position feedback in servomechanisms, and for automated measurement in machine tools and many other industrial and scientific applications.

# Linear Variable Differential Transformer (LVDT)

## Advantages:

1.Linearity. 2.Infinite Resolution 3.High output

4.High sensitivity 5.Less friction

6.Low power consumption

## Disadvantages:

1.Error due to temperature.

2.Affected by vibrations.

3.Temperature also affected by transducer.

## Applications:

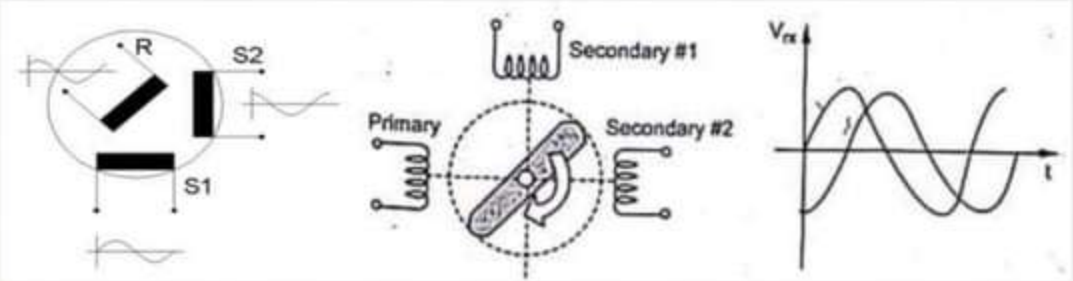
1. Acting as a secondary transducer, LVDT can be used as a device to measure force, weight and pressure,
2. Testing of soil strength
3. PILL making Machine
4. "Brain Probing" medical device 5. Robotic Cleaner 6. Dollar bill thickness in ATM Machine. 7. Hydraulic cylinder Displacement.

# Resolvers

- A resolver is an electrical transformer that is used to measure the angle of rotation.
- Most of the resolvers look similar to an electrical motor with a machine metal rotor and copper windings on the stator.
- Function of the resolver is to resolve a vector into its components(Sine and Cosine). They convert sine and cosine signal to binary signal (10 to 16 bit wide) that can more easily be used by the controller.
- Resolver is also called sine cosine generator and synchro resolver.
- Voltage form an Primary (input) winding, into secondary (output) windings with a magnitude.

# Resolvers

- Construction and Working:




- The stator portion of the resolver houses three windings: an exciter winding and two two-phase windings
- Rotary transformer that consist cylindrical rotor and stator.
- Rotor and stator are manufactured Multi slot laminations and two set of windings.

# Resolvers

- It consists Three coils. One of the coil rotates, while the other two remains stationary at a 90° distance.
- Two stationary coil receive current in the same manner at the rotating coil.
- Coil determines the angular displacement of the object.
- Windings for a single speed resolver create one complete sine curve and cosine curve in one mechanical revolution.
- Multispeed resolver create multi sine and cosine curves in one mechanical revolution.
- Single speed give absolute feedback and accuracy Compare to multi speed.

# Resolvers

Advantages:

1.Infinite resolution 2.Digtial signal of finite solution

Disadvantages:

1.Heavy 2.Expensive 3.Bulky

Applications:

1.Phase shifting.

2.Determines the vector angle and component.

3.Controlling the amplitude of pulses and also in pulse resolution.

4.Vector resolution.

# Optical Encoders

- An optical encoder is an electromechanical device which has an electrical output in digital form proportional to the angular position of the input shaft.
- Optical encoders enable an angular displacement to be converted directly into a digital form.
- Optical encoder use pulses of light to represent data. These light waves are them analyzed to reveal such variable as position, direction or velocity.
- Rotary application ,the optical encoder responds to the rotating shaft and receives movement related data.
- In linear application used to determine an object exact position in relation to the encoder.
- Construction:
- It consists of rotating and stationary electronic circuit.
- Rotor has a metal or glass or plastic disc mounted on the encoder shaft.
- Encoder is an angular position sensor

# Optical Encoders

- It has shaft mechanically coupled to an input driver, which rotates a disc rigidly fixed on it.
- Angular displacement to be converted directly into digital form.

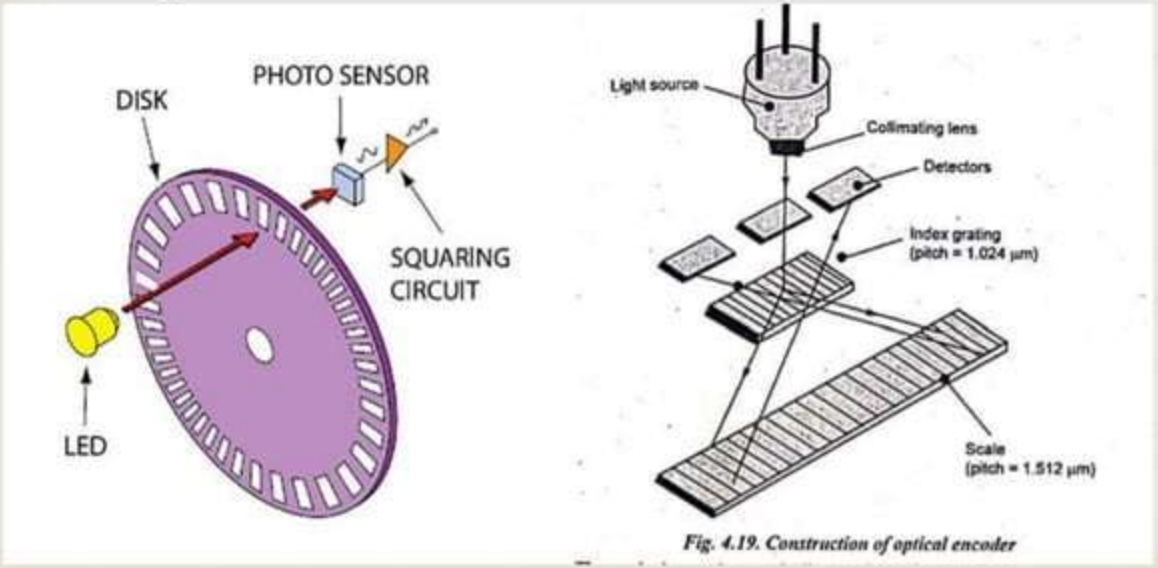



*Fig. 4.19. Construction of optical encoder*

# Optical Encoders

- Working principle:
- Optical encoder operate by counting scale lines use of light source and photo detector.
- Which is used to determine the relative position between a scanning head and linear scale.
- It is mounted between the Light source and photo cell.
- Light sources created by lines on the glass.
- Photocell is multiplying the Frequency of the photo cell.

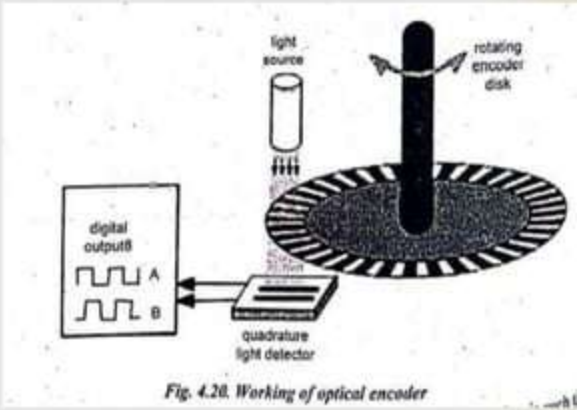


Fig. 4.20. Working of optical encoder

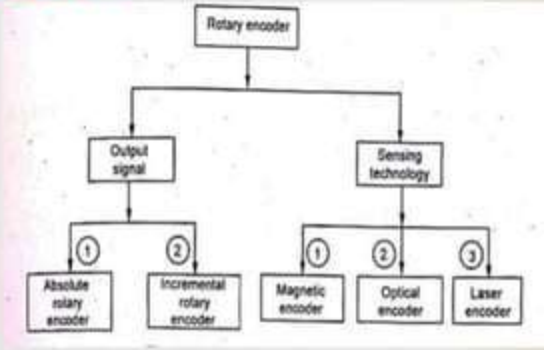
# Optical Encoders

- Two output wave forms are 90° out the phase called quadrature signals. This signals that produce two channels, such as channel A and B.
- When optical encoder rotated in a clockwise direction, channel 'A' leads Channel 'B'.
- In counter clock wise direction channel 'B' leads Channel 'A'.
- Quadrature encoder will doubles (X2) the number of pulses per revolution in one channel.
- Quadrature encoder will quadruple (X4) the number of pulses per revolution in both channels.

# Optical Encoders

- Types of optical encoder:

1. Optical rotary encoder
   - A). Absolute rotary encoder.
   - B). Incremental rotary encoder
2. Optical linear encoder




## Optical rotary encoder:

- A rotary encoder using sensing technology replies on the rotation of an internal code disc that has opaque lines and patterns on it.
- Encoder converts the electronic pattern into an electrical signal.
- Absolute rotary encoder.
- Measurement range or angle or angle by definite code on a glass or plastic disc.
- Disc creates from light and Dark region with different tracks

# Optical Encoders

- Combination related Absolute Numerical value.
- Invalid values caused by interference
- Loss of the supply voltages.
- While disc is rotating switching the output signal 'ON' or 'OFF' by the Variations of light source.

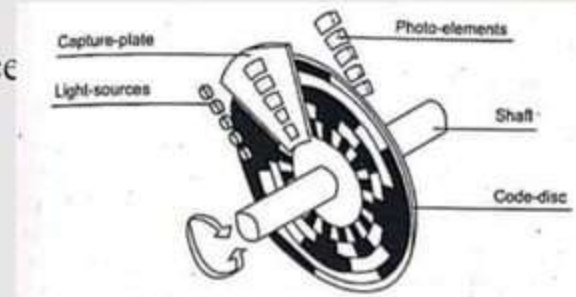



*Fig. 4.15. Working principle of absolute encoder*

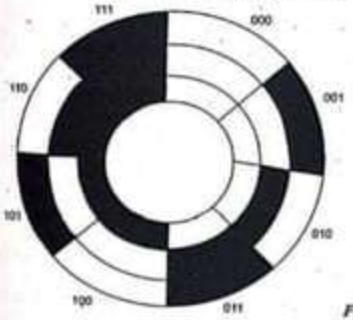



*Fig. 4.16. Absolute encoder*

Applications:

1. Automative
2. Paper industry
3. Renewable energy
4. Mobile Equipment
5. Machine and Plant Engineering.

# Optical Encoders

- Incremental rotary encoder:
- It consists of 1.Rotating disk 2.Light source(LED)3.Photo detector 4.Encoder shaft 5.Mask 6.Transparent code disc 7.Opaque graduations.

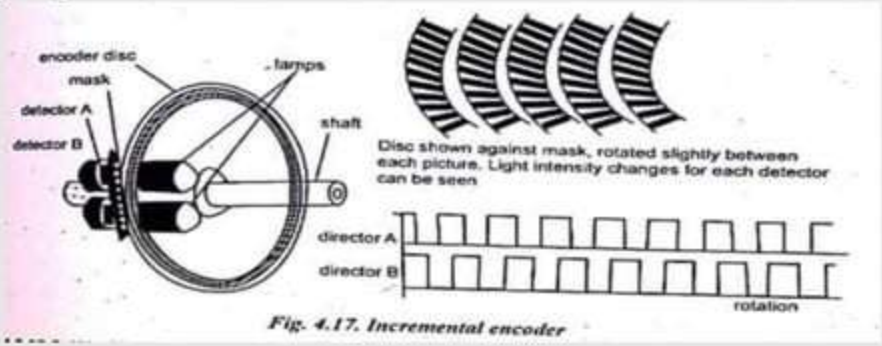


*Fig. 4.17. Incremental encoder*

- Working Principle:
- Disc rotates the light emitted onto photo detectors, generating a digital or pulse signal output.

# Optical Encoders

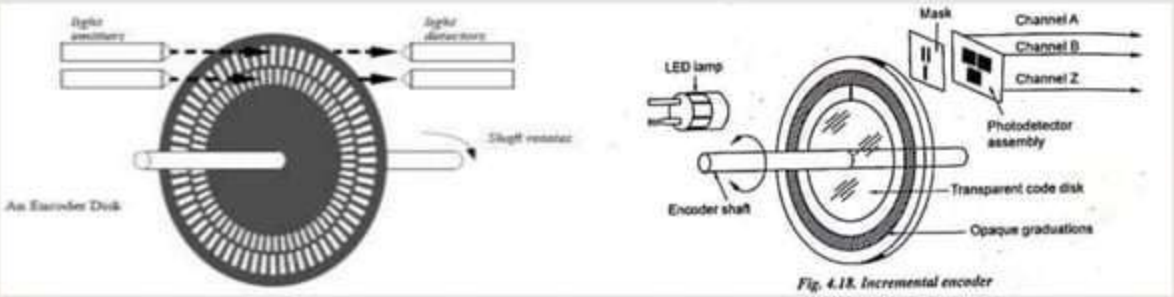



*Fig. 4.18. Incremental encoder*

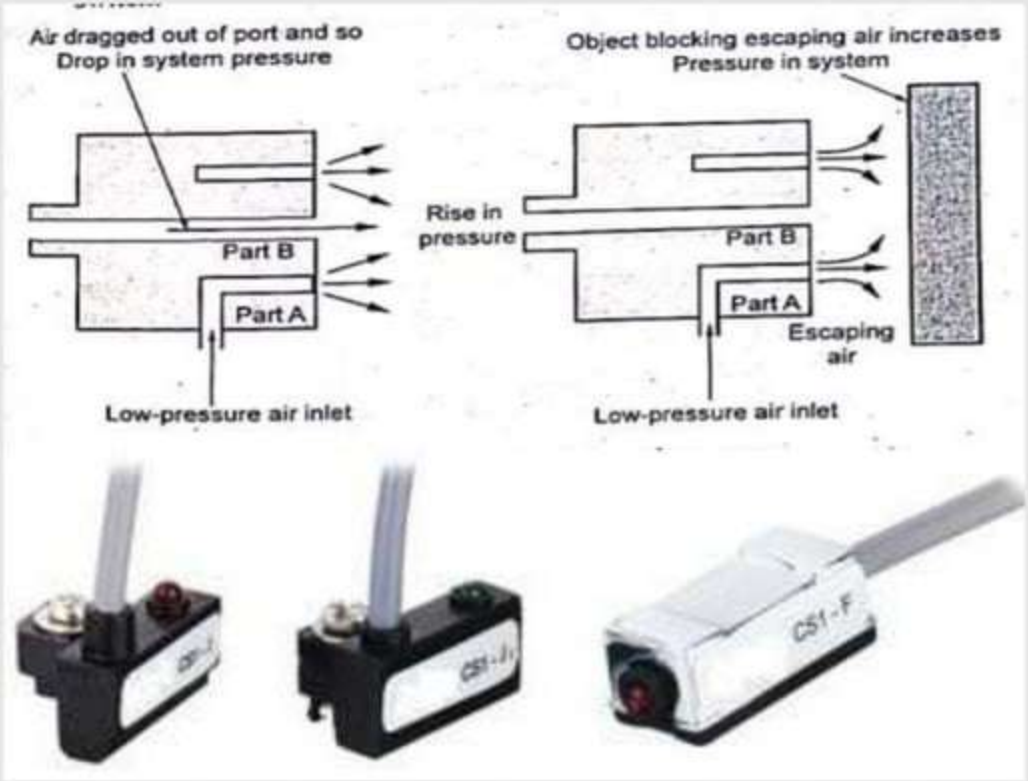
- To determine direction a two channel.
- To output channels A and B to sense the position.
- Sensor positioned 90° out the phase encoder indicates both position direction or rotation
- 'A' leads 'B' disk rotating in a clockwise direction.
- 'B' leads 'A' disk rotating in a counter clockwise direction
- Application:
- 1.Food and Beverage 2.Oil and Gas industries 3.Doors gates and elevators 4.Machine and Plant Engineering.

# Pneumatic Position Sensors

- Working Principle:
- **Pneumatic** cylinders use **sensors** to detect the linear **position** of the piston for applications where **position** feedback is crucial. The most common type of **sensor** used for **pneumatic** cylinders are magnetic proximity **sensors**, which detect the magnetic field of a magnet integrated in the cylinder piston.
- The sensor is mounted onto the pneumatic cylinder's body and will indicate "ON" or "OFF" based on proximity to the magnet. Depending on the application, various different magnetic proximity sensor technologies can be used to maximize performance, space, and reliability.

# Pneumatic Position Sensors

- Description:
- Which is used to measure the displacement as well as to sense proximity of an object.
- Sensor measure some aspect of the system operated by air or gas under pressure.
- This sensor are transducer generating an electrical signal in proportion to the pressure to be monitored by range of electronic device.
- Resistance is used to modify the output voltage of the sensor


Air dragged out of port and so
Drop in system pressure
Part B
Part A
Low-pressure air inlet
Rise in
pressure
Object blocking escaping air increases
Pressure in system
Part B
Part A
Escaping
air
Low-pressure air inlet
CS1-F

# Pneumatic Position Sensors

- Low pressure air (Port A) there is raise in pressure in output port 'B'
- This raise in pressure is Calibrated to measure the Displacement or trigger a switch.

Advantages:

1.Clean 2.Overload safe 3.Control the speed and force

4.Explosion proof

Disadvantages:

1.High Cost 2.Preparation is required

3.Limited range of force.

Application:

1.CNC Machines

2.Robotics 3.Automotive

# Range Sensors Triangulations Principles

- Laser triangulation sensors determine the position of a target by measuring the reflected light from the target surface.
- Based on their intended application and performance, these sensors can be classified into two categories.
- High resolution lasers are generally utilized in position and displacement monitoring applications that require stability, high precision and low temperature drift.
- Proximity type laser triangulation sensors are often employed to detect the presence of a component, or utilized in counting applications.
- They are also less expensive when compared to other high performance technologies.

# Range Sensors Triangulations Principles

- Laser light projects a spot of light a position 'A'.
- Sensor spot on surface is formed at position 'B'
- Position the Image spot and calculating the angles involved.
- Optical magnification of the imaging lens or the angle between and the laser beam and imaging axis

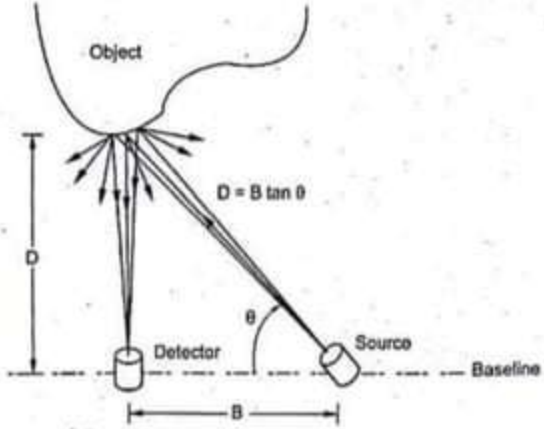



*Fig. 4.41. Triangulation technique*

# Range Sensors Triangulations Principles

Advantages:

1.Very high Accuracy

2.High reflective mirrored objects.

Disadvantages:

1.Expensive system

2.High setup costs

3.Slow image acquisition time

Application:

1.Space craft location

2.Radar

3.Turbine blades 4.Road surfaces process industry.

5.Tunnels and Ships.

# Structured Lighting Approach

- Structured light is the process of projecting a known pattern on to a scene.
- Objects in the scene as used in structured light 3D scanners.
- Working Principle:
- It is working method of optical ranging based on triangulation.
- Laser with objects in the scene can be observed by a video camera.
- This sensor is more accurate and very clear range data .

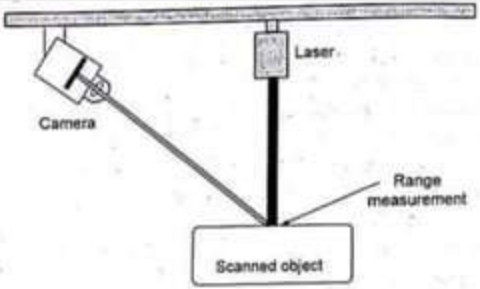



*Fig. 4.42. Structural light*

# Structured Lighting Approach

- The structured light sensor uses a plane of laser light.
- Profile of the range data in each camera image. The sensor has no moving optical components
- Advantages:

1. High accuracy.
2. Works with homogeneous surfaces.
3. Analog system used in digital.

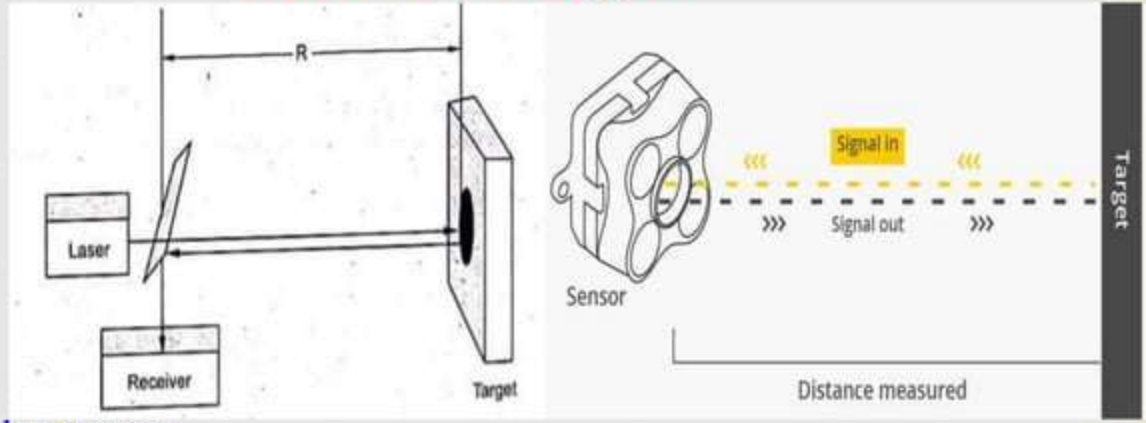
- Disadvantages:

1. Complex image processing
2. Sensible to double reflection
3. Analog system more expensive
4. Digital systems are less accurate.

# Time of Flight

- The Time-of-Flight principle (ToF) is a method for measuring the distance between a sensor and an object, based on the time difference between the emission of a signal and its return to the sensor, after being reflected by an object.
- Various types of signals (also called carriers) can be used with the Time-of-Flight principle, the most common being sound and light.
- Tera Ranger sensors use light as their carrier because it is uniquely able to combine higher speed, longer range, lower weight, and eye-safety.
- By using infrared light we can ensure less signal disturbance and easier distinction from natural ambient light, resulting in the highest performing distance sensors for their given size and weight.

# Time of Flight




Advantages:

1.Mass resolution 2.Greater sensitivity 3.Rapid acquisition

4.Simple and Compact

5.Fast Distance algorithm

Disadvantages:

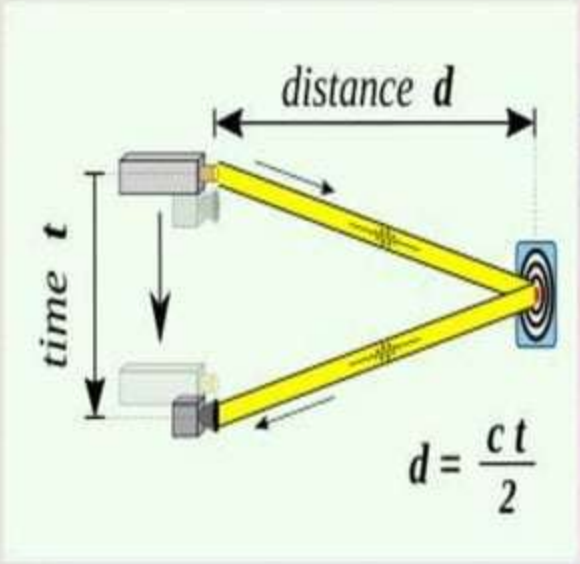
1.Background light or multiple reflection.

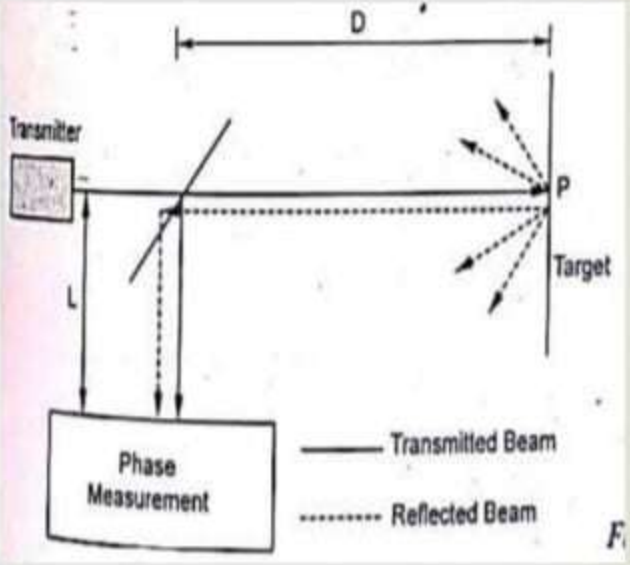
2.Low dynamic application.

# Light based Laser Range Finders

- A laser light is very useful for tracking and detection a target located at a long distance.
- The distance between sensor and target is measured by calculating the speed of the light and time.
- The device uses laser technology to measure distance.
- Working Principle:
- The range finders emits laser beam at the push of a button.
- Infrared lights to travel to the target. The speed of the light is constant.
- Amount of time is time is directly proportional to the distance.

# LASER Distance Measurement



# Light based Laser Range Finders

Advantages:

1.Faster shoot 2.Very accuracy and Precise

3.High resolution

4.High speed sensor.

Disadvantages:

1.Canot identify mirrors and glass.

2.Heavier and larger than all other sensors.

Applications:

Road range

2.Construction industry

3.Electricity installation industry

# Laser Range Meters

- Laser range meter uses laser technology to measure distance.
- Laser distance meter sends a pulse of laser light to the target and measures the time its takes for the reflection to return.
- Distance up to 30m accuracy

Working Principle:

- Laser distance meter emits a pulse of laser at target.
- Constant speed through the earth atmosphere.

# Laser Range Meters

- Computer calculates the distance to target.
- The distance between the meter and target is given by

$$D=ct/2$$

Where,

c- speed of light, t-Amount of time for round trip between meter and target.

Advantages:

1.Flexiable 2.Easy to integrate 3.Powerful and Fast

4.Reliable and Robust 5. High Accuracy

Application:

1.Automation

2.Scanning system

3.Industrial metrology 4.Transport and Conveyor Technology.

# Touch Sensors

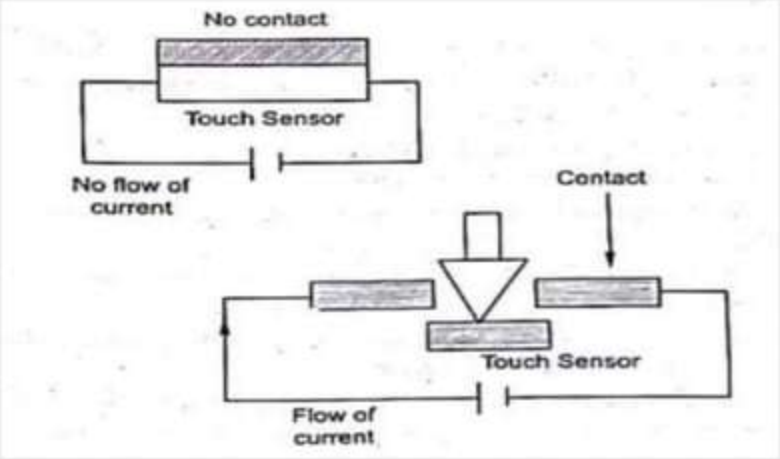
- A touch sensor is a type of equipment that captures and records physical touch or embrace on a device and object.
- It enables a device or object to detect touch, typically by a human user or operator.
- Example: Digital Sensor

## Working Principle:

- It is working of a sensor is similar to that of a simple switch.
- Surface of the touch sensor the circuit is closed inside the sensor and there is flow of current
- When contact is released the circuit is opened and no currant flows.

# Touch Sensors

- Some of the commonly used simple devices micro switches, limit switches.
- These sensors are mostly use robot obstacles.
- It can be reversed,turned,switched ON and stopped.



# Touch Sensors

Advantages:

1.Durable

2.Esaily readable.

3.Simple construction

4.Good dynamic range.

Disadvantages:

1.Hysteresis

2.Non Linearity

3.Low sensitivity.

Application:

1.Smart phone

2.Tablet computer

# Binary Sensors

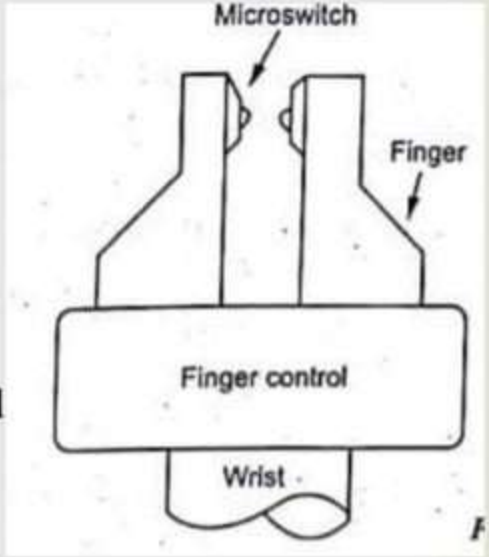
- Binary sensors gather information about the state of devices which have a "digital" return value (either 1 or 0). These can be switches, contacts, pins, etc.
- These sensors only have two states: **0/off/low/closed/false** and **1 /on /high /open /true**. Knowing that there are only two states allows Home Assistant to represent these sensors in a better way in the frontend according to their functionality.
- Binary sensor only have two states ON (or) OFF "0" (or) low (or) closed (or) false and "1"

  (or) ON (or)High (or)Open (or)True.
- Binary sensor which have either the state ON or OFF
- Sensor create a binary output signal to indicate the contact object.

# Binary Sensors

Working Principle:

- Sensor are contact switch which is placed on the inner side of the each finger.
- Object making contact with its surface. Provide more tactile information.
- Control signal for directing the hand over the work piece.
- They binary sensor detects whether the robot or object has crossed it.
- Information will be utilized in identifying the presence of object.



# Binary Sensors

Advantages:

1.Reliable

2.Low cost

3.Simple to operate

4.Error is low.

Disadvantages:

1.No failure recovery model.

2.No consideration for energy efficiency

Application:

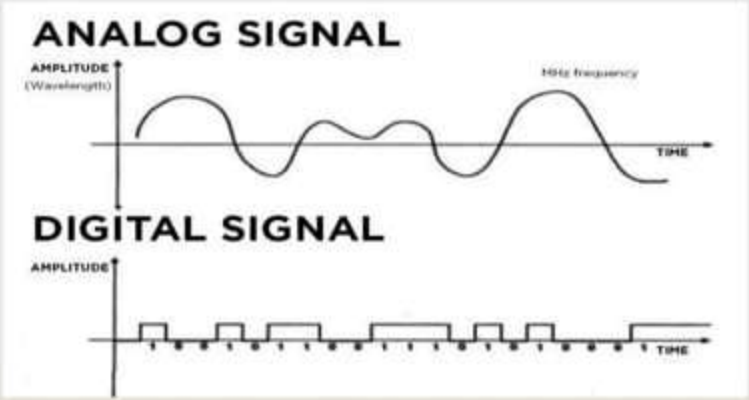
1.Transportation

2.Communication

3.Chemical Engineering

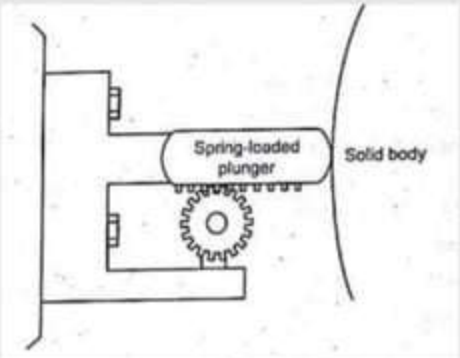
# Analog Sensors

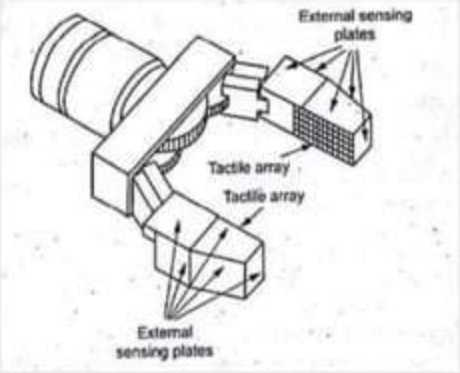
- **Analog Sensors** produce a continuous output signal or voltage which is generally proportional to the quantity being measured.
- Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc are all **analog** quantities as they tend to be continuous in nature.
- Trigger ON or OFF signals as the target moves IN or OUT of Sensing Range



# Analog Sensors

- Device whose output is proportional to a local force.
- Spring Loaded rod linked to rotating shaft.
- Potentiometer or digitally using a code wheel.
- External sensing plates are typically binary devices.
- Inner surface fingers has Been Covered with tactile Sensing array.
- The letter easily transformed into electrical signal, Whose amplitude is proportional to force.



# Analog Sensors

Advantages:

1.Low cost

2.Less error

3.Less bandwidth

4.Easy construction

5.More Precise

Disadvantages:

1.Degradation occur

2.Noisy Operation

Uses:

Used to measure the amount of pressure applied sensor

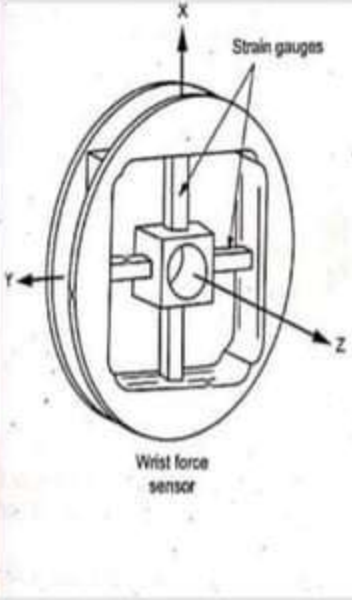
# Wrist Sensors

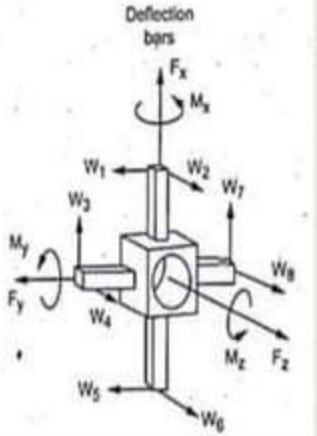
- Wrist sensors is designed to worn on the wrist and provide accurate capture of pressures exerted on the wrist.
- Wrist force sensor can detect and measures these forces.
- Components of Wrist force sensor:

1. Metallic frame
2. Bracket for tool monitoring and strain gauge.

- It is a small sensitive light weight,10cm total diameter 3cm thickness, dynamic range up to 200lb

# Wrist Sensors



# Wrist Sensors

- Eight pairs of strain gauge are used Normally X,Y and Z axes of the force co ordinate frame.
- 3 components of force F
- 3 components of moment M
- Determined force by properly adding and subtracting the output voltages respectively.
- Sensor reading by sensor calibration matrix.
- Measure the component of force and torque acting on the base.
- Base is firmly mounted on a solid surface and no provisions are made for pedestal sensing.
- Pedestal sensing is similar to used wrist sensing.

# Wrist Sensors

- Specialized pressure sensor known as stain gauge.
- Converts wrist force into Electrical signals.
- Robot arm joints the end effector.The point is called wrist. One or more joints that moves in various ways.
- Orientation are right & Left, in & out, Up & Down.
- Rotation along all three axes.
- Must detect Translate also.

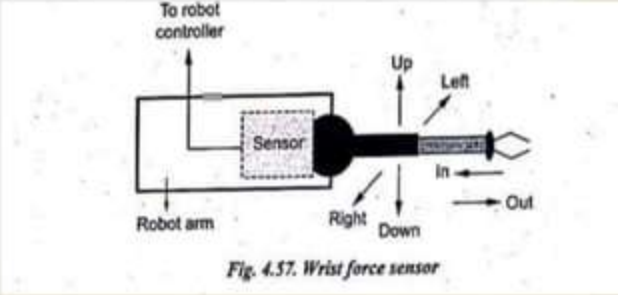



*Fig. 4.57. Wrist force sensor*

# Wrist Sensors

Advantages:

1.High Performance.

2.Better frequency.

3.Good Accuracy.

Disadvantages:

1.Expensive

2.Less linearity.

3.Sensitive to temperature change.

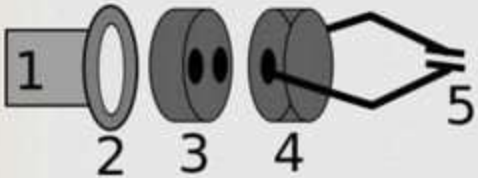
Specification:

1.High Stiffness 2.Compact Design 3.Linearity

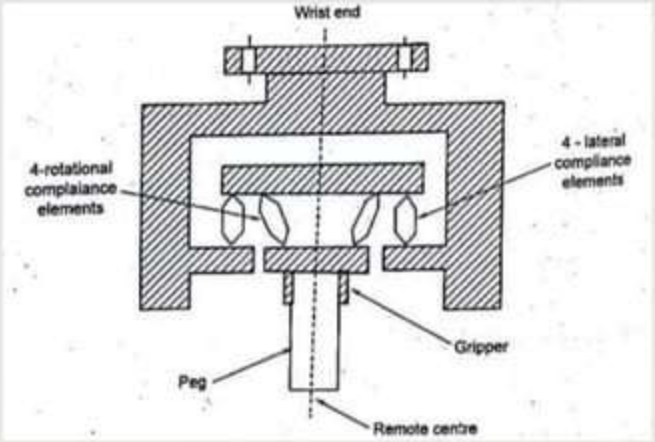
4.Low hysteresis and internal friction

# Remote Center Compliance Sensors(R.C.C)

- It is a mechanical device that facilities automated by preventing peg like objects from jamming into a hole with tight clearance.
- Robot might pick up a hook with its gripper.




1. Robot wrist,
2. Attachment ring,
3. RCC, 4. Gripper mechanism,
5. Gripper fingers



# Remote Center Compliance Sensors(R.C.C)

- RCC has Three types of compliance.

1.Lateral 2.Rotational 3.Axial.

- Four Lateral and four rotational with RCC Elements.
- Eight elements together provide the axial compliance.

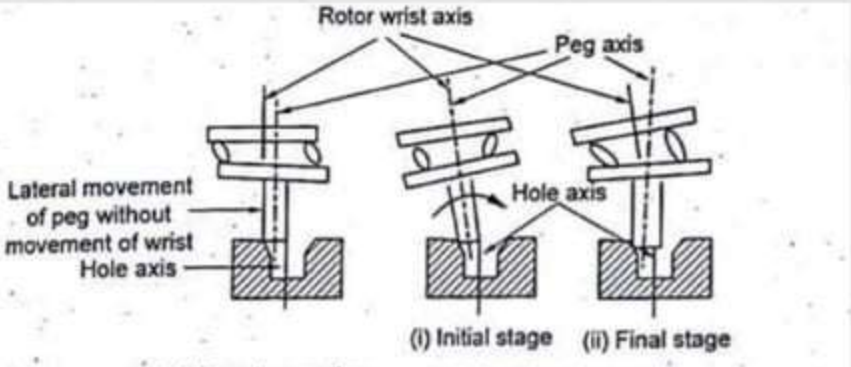



*Fig. 4.63. The working of RCC device*

# Remote Center Compliance Sensors(R.C.C)

- Advantages:
- Reducing contact force
- Preventing galling and jamming.
- Lateral and rotational misalignment.
- RCC reduce damage to material during the assembly process.
- Benefits:
- Automotive Assembly
- Impossible assemblies possible

# Slip Sensors

- Is the measurement and detection of the movement of an object relative to the sensor.
- Interpretation the data from touch sensor or tactile array.
- It is provided the robotic manipulator if the object is carried by the end effectors is slipping.

Working Principle:

- Slip sensor is based on sensing plates.
- The slip during job handling causes the molecular disturbance.
- End Effecter to increase the pressure of holding.

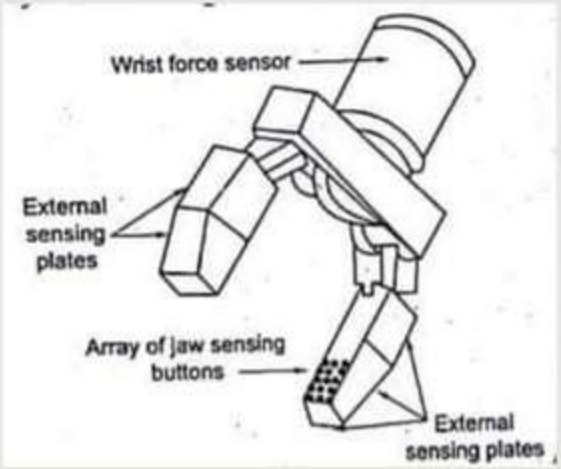
# Slip Sensors

Features of slip sensor:

1.The slip sensor can be measured quantitatively.

2.Measurement has good accuracy.

3.Measured the velocity of arm.



# Slip Sensors

Advantages:

1.Lower cost 2.Simple structure

3.High reliability 4.High flexibility

Disadvantages:

Complex output change occur.

Application:

1.Smart robots.

2.Medical surgery

3.Implantable medical devices.

4.Slip control under manipulation.