

Sensors and Transducers

A series of horizontal lines in teal and light blue colors, with varying lengths and offsets, creating a modern, layered effect across the middle of the slide.

Introduction

- To be useful, systems must interact with their environment.
To do this they use sensors and actuators
- **A sensor is a device that converts a physical phenomenon into an electrical signal.**
- Sensors represent part of the interface between the physical world and the world of electrical devices, such as computers.
- The other part of this interface is represented by *actuators*, which convert electrical signals into physical phenomena

Sensor Performance Characteristics

Transfer Function

- The transfer function shows the **functional relationship between physical input signal and electrical output signal.**
- Usually, this relationship is represented as a graph showing the relationship between the input and output signal, and the details of this relationship may constitute a complete description of the sensor characteristics.

Sensitivity

- The sensitivity is defined in terms of the relationship between input physical signal and output electrical signal.
- It is generally the **ratio between a small change in electrical signal to a small change in physical signal.**
- As such, it may be expressed as the derivative of the transfer function with respect to physical signal.

Span or Dynamic Range

- The range of input **physical signals** that may be **converted to electrical signals by the sensor is the dynamic range or span.**
- Signals outside of this range are expected to cause unacceptably large inaccuracy.
- Typical units are kelvin, Pascal, newton, etc.

Accuracy or Uncertainty

- Uncertainty is generally defined as the **largest expected error between actual and measured output signals.**

Eg.: An accuracy of 0.001 means that the measured value is within 0.001 units of actual value.

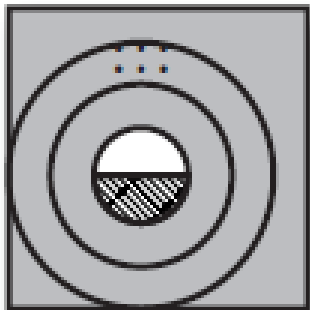
- “Accuracy” is generally considered by metrologists to be a qualitative term, while “uncertainty” is quantitative.

Eg.: one sensor might have better accuracy than another if its uncertainty is 1% compared to the other with an uncertainty of 3%.

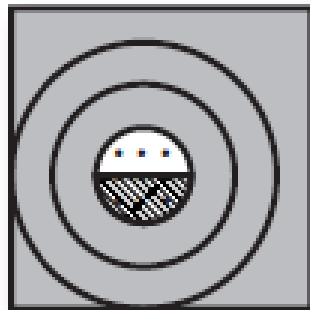
Precision

- Precision is the ability of an instrument to reproduce a certain set of readings within a given accuracy.
- Precision is dependent on the reliability of the instrument.

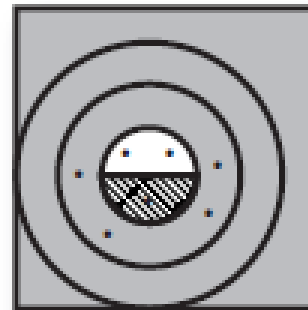
TARGET SHOOTING EXAMPLE



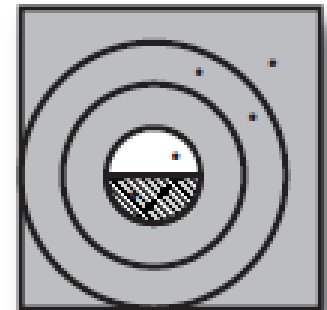
Poor accuracy,
High precision



High accuracy,
High precision



Good average accuracy,
Poor precision



Poor accuracy,
Poor precision

Nonlinearity (often called Linearity)

- The maximum deviation from a linear transfer function over the specified dynamic range.

There are several measures of this error.

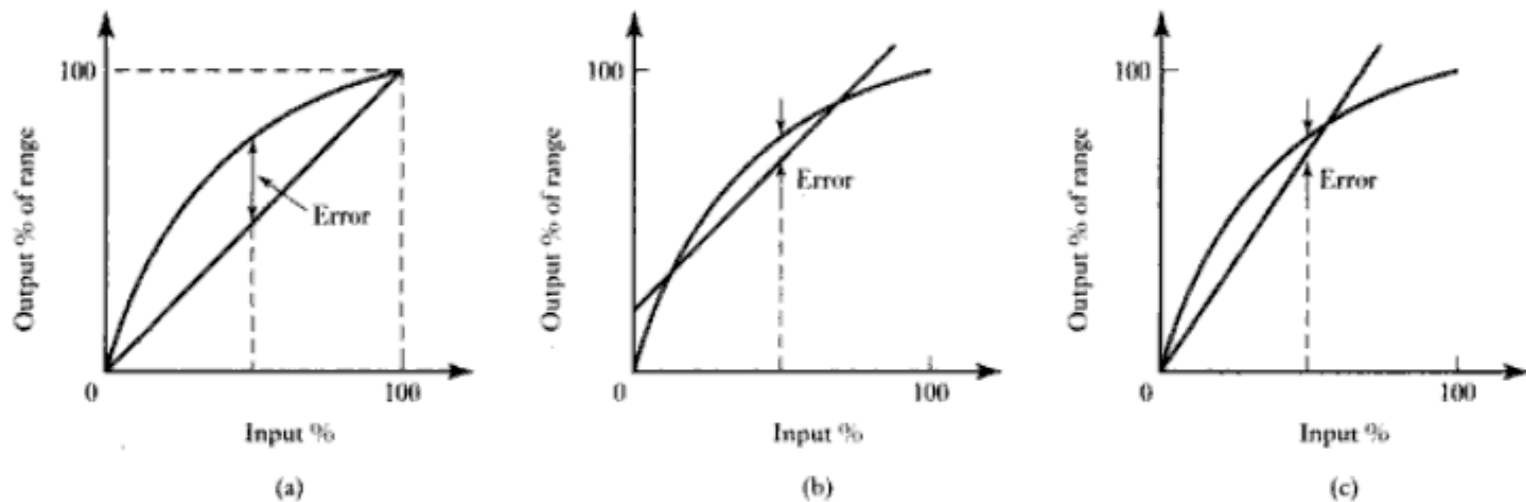


Figure 2.2 Non-linearity error using: (a) end-range values, (b) best straight line for all values, (c) best straight line through zero point.

Resolution

- When the input varies continuously over the range , the output signals for some sensors may change in small steps
- The **smallest increment in the measured value that can be detected.**
- Also known as degree of fineness with which measurements can be made.

Stability

- **Ability of a sensor to give the same output when used to measure a constant input over a period of time.**
- ‘Drift’ – Change in output that occurs over a time
- ‘Zero drift’ – Changes that occur in output when there is zero input

Dead Band: Range of input values for which there is no output

Dead time: Length of time from the application of an input until the outputs begins to respond and change

Output Impedance

- Inclusion of the sensor significantly modify the behavior of the system to which it is connected
- Output impedance of sensor is being connected in either series or parallel with the circuit

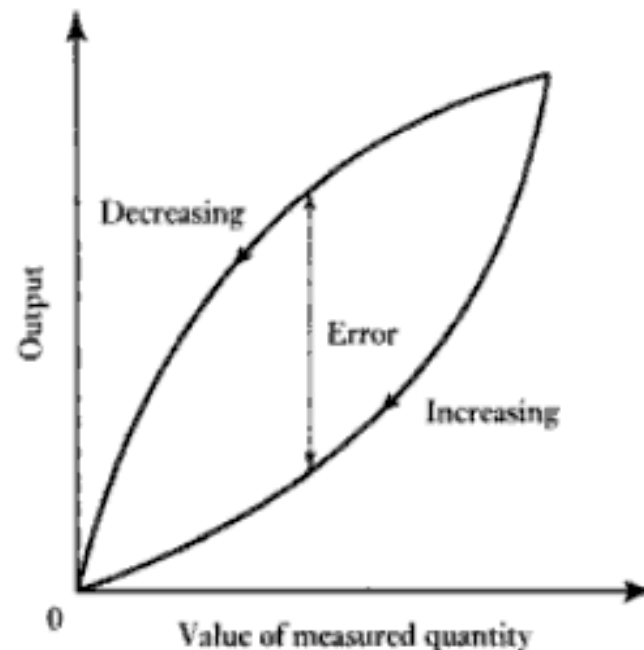
Repeatability/Reproducibility

- **Sensor's ability to give the same output for repeated applications of the same input value**
- Expressed as percentage of full range output

$$\text{repeatability} = \frac{\text{max.} - \text{min. values given}}{\text{full range}} \times 100$$

Hysteresis error

- Sensors can give different outputs from the same value of quantity being measured according to whether that **value has been reached by a continuously increasing change or a continuously decreasing change** – this effect is called Hysteresis
- Maximum difference in output for increasing and decreasing values



Selection parameters

- Nature of the measurement required
- Nature of output required from the sensor
- Range
- Accuracy
- Linearity
- Speed of response
- Reliable
- Maintainability
- cost

Role of sensor/transducer in mechatronics

- Provides position, velocity and acceleration information of the measuring element
- Acts as protective mechanism for a system
- To eliminate complex & costly feeding and sorting devices
- Provides identification and indication of the presence of different components
- Provides real time information concerning the nature of the task being performed

Sensor Classification

- Based on Signal Characteristics:
 - Analog
 - Digital
- Based On power Supply:
 - Active
 - Passive
- Based on Subject of measurement: Acoustic, Biological, Chemical, Electric, Mechanical, Optical, Radiation, Thermal, etc..

Analog Sensors:

- Typically have an output that is proportional to the variable being measured.
- **The output changes in a continuous way**

Digital sensors:

- **Outputs are digital in nature. i.e. a sequence of essentially on/off signals which spell out a number whose value is related to the size of the variable being measured.**
- Known for accuracy, precision and do not require any converters when interfaced with a computer monitoring system

Active sensors:

- **Requires an external source of excitation.**
- Resistor-based sensors such as thermistors, RTDs (Resistance Temperature Detectors), and strain gages are examples of active sensors, because a current must be passed through them and the corresponding voltage measured in order to determine the resistance value.

Passive Sensors:

- **Generate their own electrical output signal without requiring external voltages or currents.**
- Examples of passive sensors are thermocouples and photodiodes which generate thermoelectric voltages and photocurrents, respectively, which are independent of external circuits.

<i>PROPERTY</i>	<i>SENSOR</i>	<i>ACTIVE/PASSIVE</i>	<i>OUTPUT</i>
Temperature	Thermocouple	Passive	Voltage
	RTD	Active	Resistance
	Thermistor	Active	Resistance
Force/Pressure	Strain Gage	Active	Resistance
	Piezoelectric	Passive	Voltage
Acceleration	Accelerometer	Active	Capacitance
Position	LVDT	Active	AC Voltage
Light Intensity	Photodiode	Passive	Current

- *Typical sensors and their outputs*

Classification of Sensors

- 1. Position sensor**
- 2. Velocity sensor**
- 3. Light sensor**
- 4. Flow sensor**
- 5. Proximity / Range sensor**
- 6. Tactile sensor**
- 7. Vision system**

POSITION SENSORS:

1. Potentiometer

- **Linear potentiometer**
- **Rotary potentiometer**

2. Encoder

- **Absolute encoder**
- **Incremental encoder**

VELOCITY SENSOR:

- **Tacho-generator**

LIGHT SENSORS:

- 1. Photo Diode**
- 2. Photo Transistor**

FLOW SENSORS:

- 1. Ultrasonic transducer**
- 2. Laser Doppler anemometer**

PROXIMITY/ RANGE SENSORS:

- 1. Ultrasonic sensor**
- 2. Eddy current sensor**
- 3. Optical proximity sensor**
- 4. Inductive proximity switch**

TACTILE SENSORS:

- 1. Micro switch**
- 2. Reed switch**

VISION SYSTEM:

- 1. Machine Vision System**

Position sensors

Position sensors are concerned with the **determination of the position of some object with reference to some reference point.**

While selecting consideration to be given:

- Size of the displacement
- Linear or angular
- Resolution, accuracy, Cost..
- Material of the measuring object.

Potentiometer

- Consists of a resistance element with a sliding contact which can be moved over the length of the element
- Used for linear or rotary displacements, by converting displacement into potential difference



Linear potentiometer:

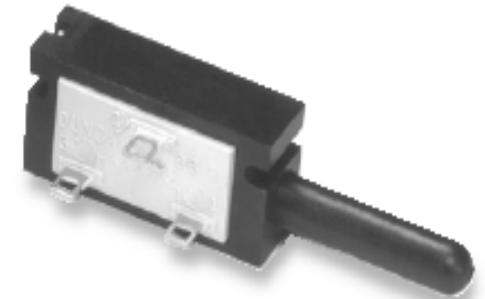
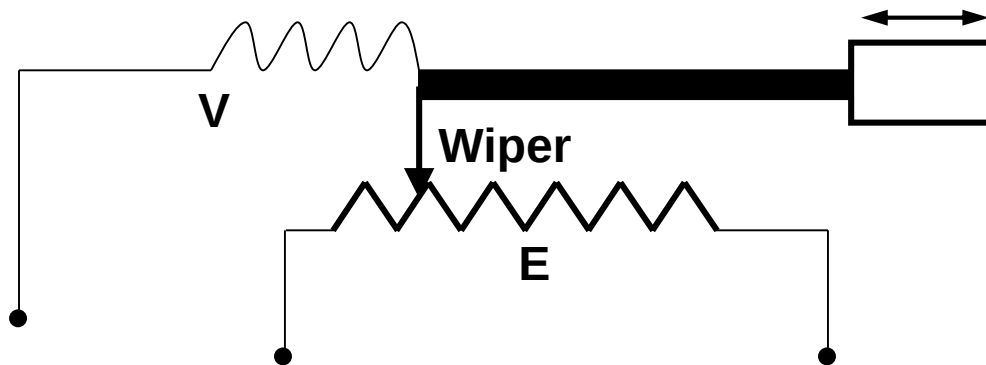
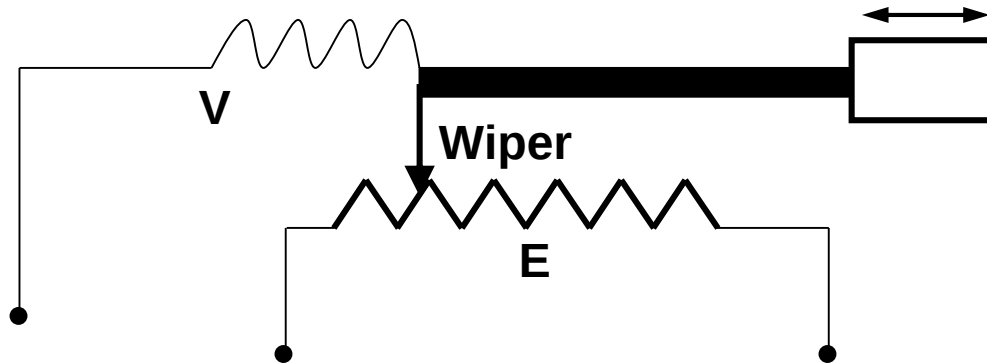


Figure: Potentiometer transducer principle

Linear potentiometer:



Voltage across the wiper of the linear potentiometer is measured in terms of the displacement 'r'

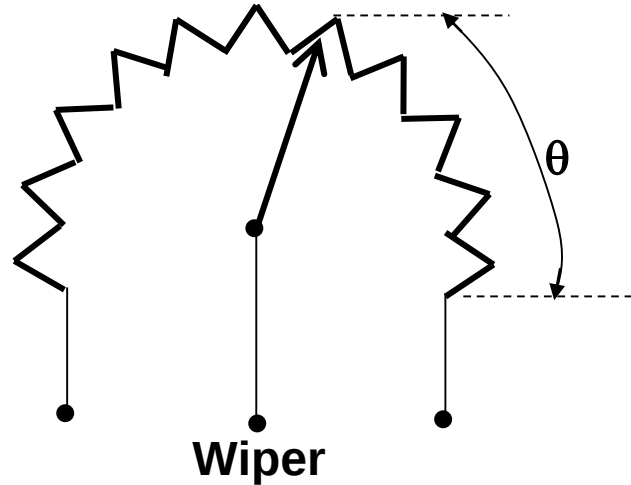
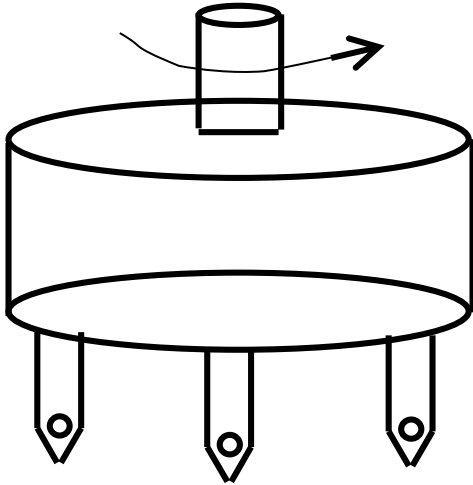
It is given by the relationship,

$$V = E \cdot \frac{r}{R}$$

$V \rightarrow$ Voltage across the pot.

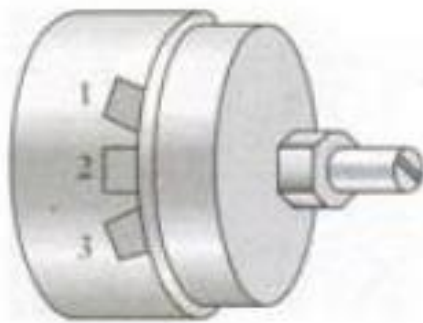
$R \rightarrow$ Full scale displacement of pot.

Rotary potentiometer:

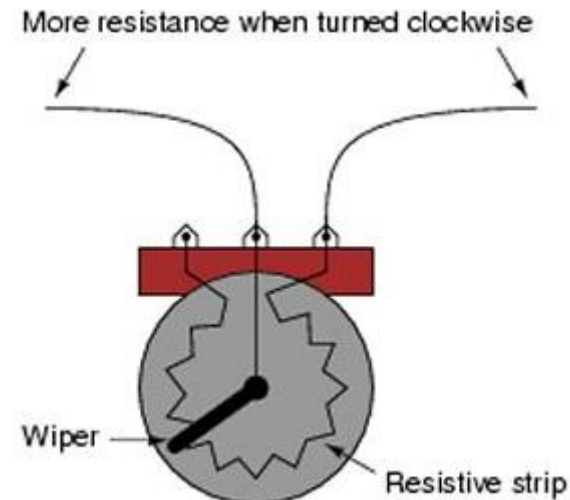


- Measures angular position
- If the track has a constant resistance/ unit length (angle), output is proportional to the angle through which slider rotates.

- The rotary potentiometer consists of a circular wire wound track or a film of conductive plastic over which a rotatable sliding contact can be rotated.
- With a constant input voltage between terminal 1 and 3 the output voltage between terminal 2 and 3 is a fraction of the input voltage, the fraction depending on the ratio of the resistance between terminal 2 and 3 compared with total resistance between 1 and 3



A rotary potentiometer



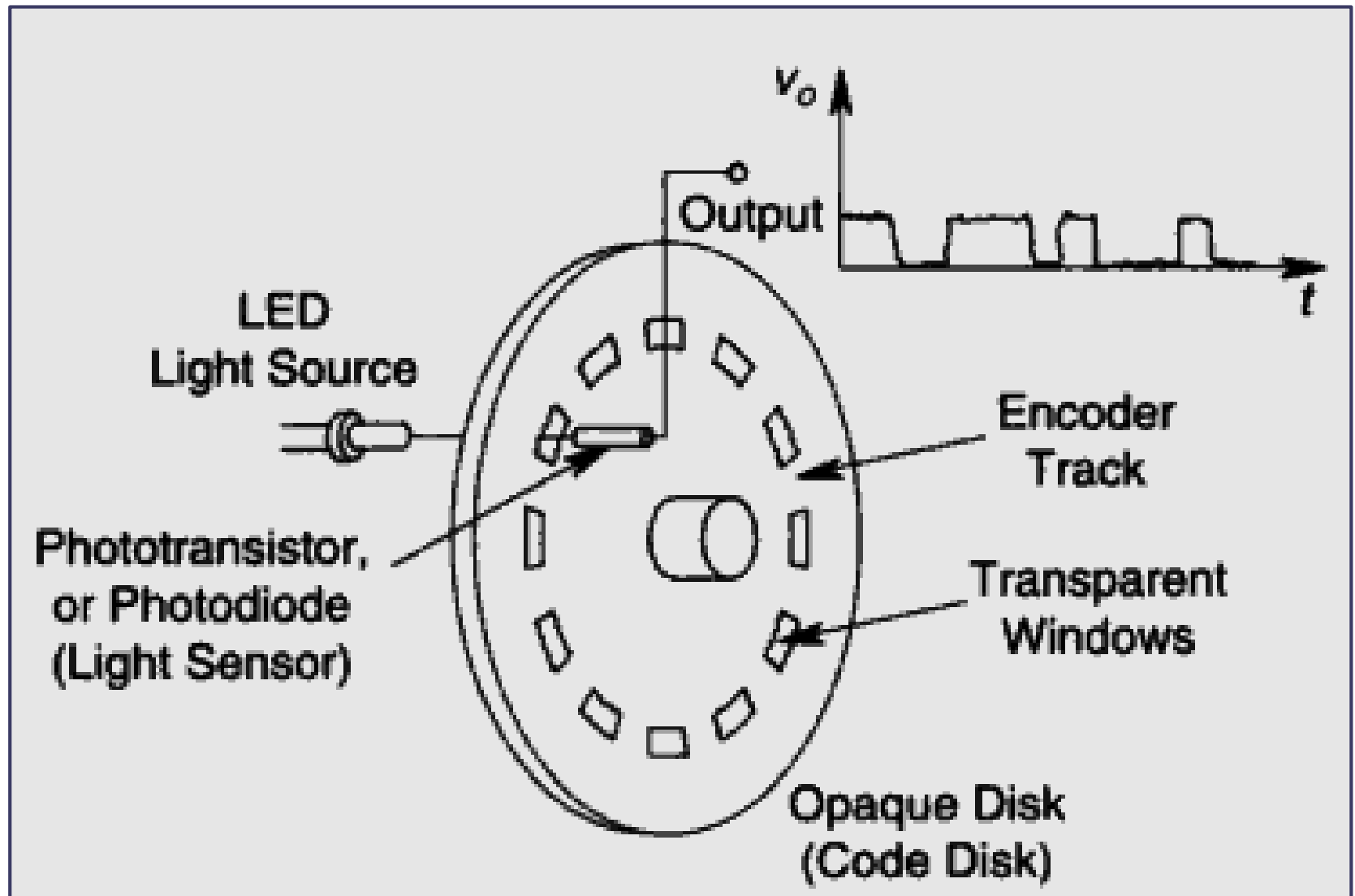
Optical Encoder

- Encoder is a device that provides a digital output as a result of a linear or angular displacement.
- These are widely used as *position detectors*.

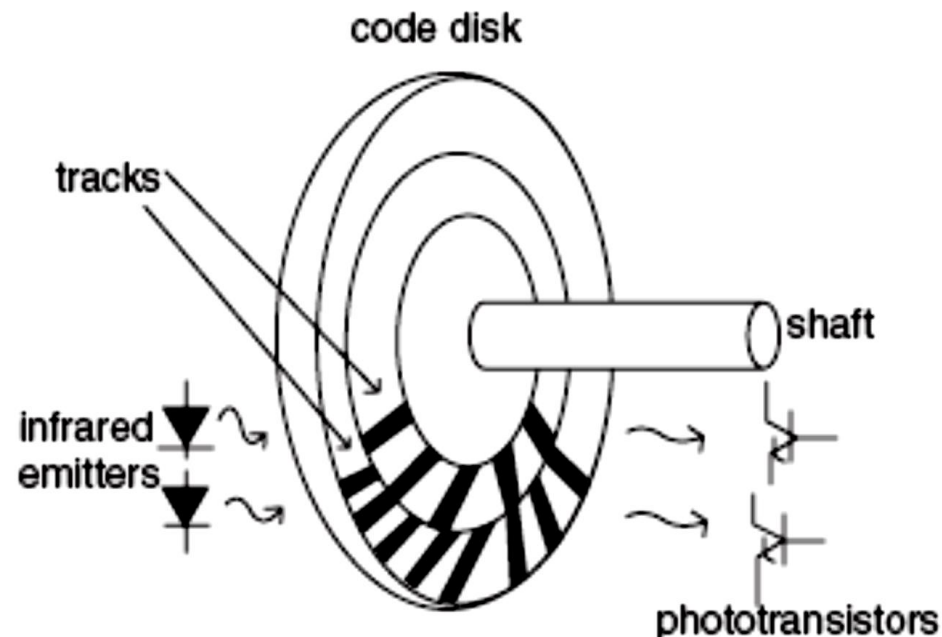
Optical Encoders

- Use light & photo-sensors to produce digital code.
- Can be linear or rotary

Optical Encoder Components



- An opaque disc with perforations or transparent windows at regular interval is mounted on the shaft whose Displacement or Speed is to be measured.
- A **LED source** is aligned on one side of the disc in such a way that its light can pass through the transparent windows of the disc.



- ✓ As the disc **rotates** the **light** will **alternately passed** through the **transparent windows** and **blocked by the opaque sections**.
- ✓ A **photo-detector** fixed on the other side of the disc detects the variation of light and the **output** of the detector after signal conditioning would be a **square wave** whose *frequency is decided by the speed and the number of holes* (transparent windows) on the disc.

Types of Optical Encoders

2 types of Optical Encoders:

- 1. Incremental**

Measure displacement relative to a reference point.

- 2. Absolute**

Measure absolute position.

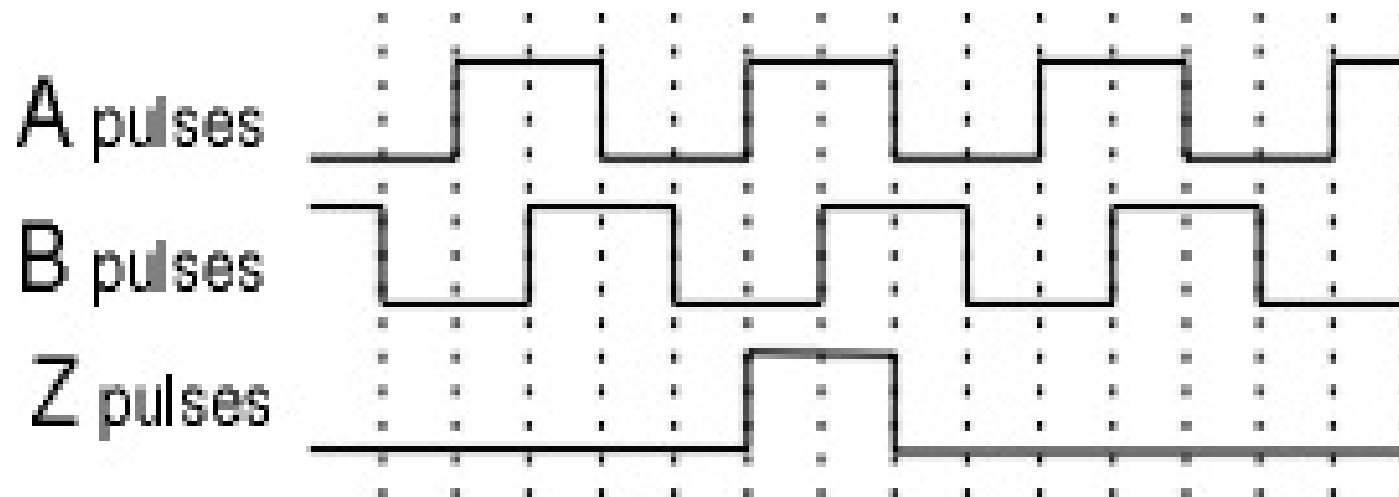
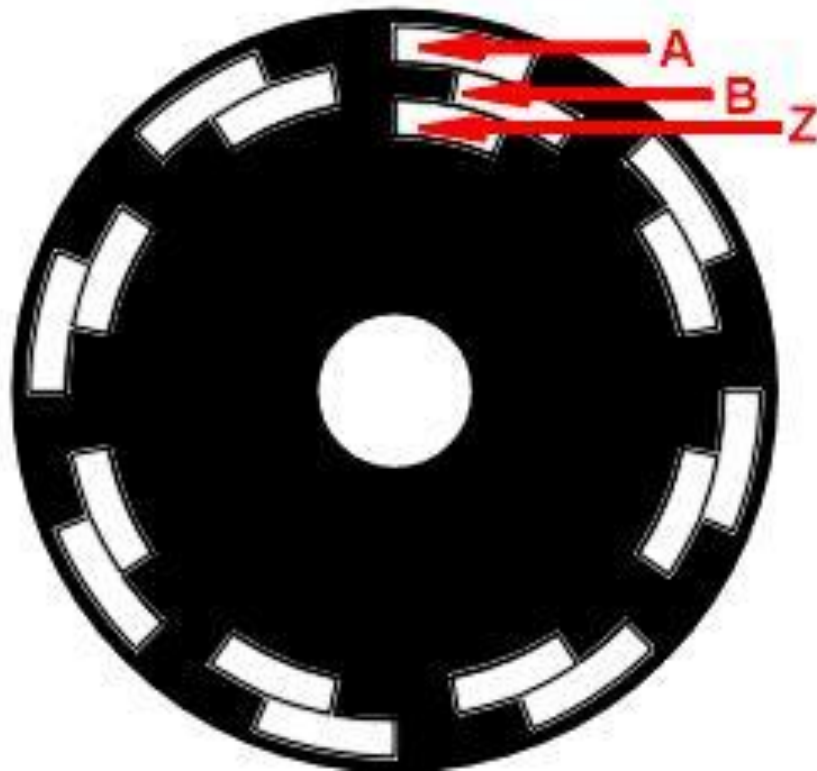
Advantages – A missed reading does not affect the next reading.

Only needs power on when taking a reading.

Disadvantages – More expensive/complex. Cost/complexity proportional to resolution/accuracy.

Incremental Encoder

- Consists 3 concentric tracks with 3 sensor pairs
- Inner track has just one hole and is used to locate the home position of the disc
- The other two tracks have a series of equally spaced holes that go completely round the disc



Incremental Encoder

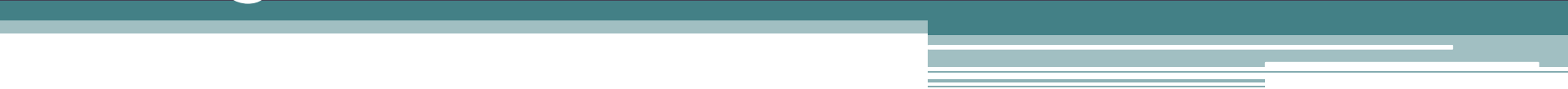
- But with the holes in the middle track offset from the holes in the outer track by one half the width of a hole
- This offset enables the direction of rotation to be determined. In a clockwise direction the pulses in the outer track lead those in the inner; and in the anticlockwise direction they lag. The resolution is determined by the number of slots on the disc. With 60 slots in 1 revolution then, since one revolution is a rotation of 360 degree, the resolution is $360/60 = 6$ degrees

- **An optical type speed sensor has a disc with 36 rectangular holes placed at regular intervals on the periphery of the disc. The frequency of the photo-detector output is 360 Hz. Find the speed of the shaft in rpm on which the disc is mounted.**

Absolute Encoder

- Gives an output in the form of a binary number of several digits, each such number representing a particular angular position.
- **3 Bit Absolute Binary Rotary encoder :** The rotating disc has three concentric circles of slots and three sensors to detect the light pulses.
- The slots are arranged in such a way that the sequential output from the sensors is a number in the binary code.

Velocity Sensors and Light Sensors

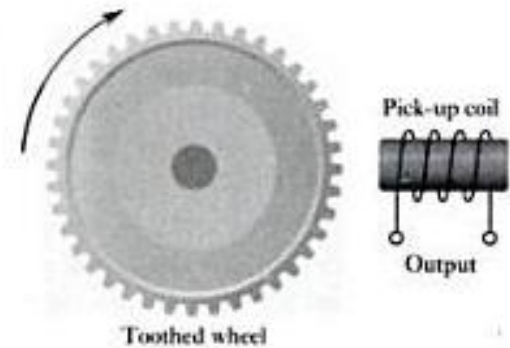
A decorative graphic consisting of several horizontal lines of varying lengths and colors (teal, light blue, and white) extending from the left side of the slide towards the right, positioned below the title.

Tachogenerator

- An electromechanical generator is a **device capable of producing electrical power from mechanical energy**, usually the turning of a shaft.
- A generator specially designed and constructed for this use is called a ***tachometer or tachogenerator***.
- Tachogenerator are frequently used to measure the speeds of electric motors, engines, and the equipment they power: conveyor belts, machine tools, mixers, fans, etc.

Variable reluctance Tachogenerator

- Consists of a toothed wheel of ferromagnetic material which is attached to the rotating shaft.
- A pickup coil is wound on a permanent magnet
- As the wheel rotates, so the teeth move past the coil and the air gap between the coil and ferromagnetic material changes.[Magnetic circuit with periodically changing air gap]
- Thus flux linked by a pickup coil changes



- The resulting cyclic change in the flux linked produces an alternating e.m.f. in the coil.
- Induced e.m.f. is given as $e = E_{\max} \sin \omega t$, where $E_{\max}$ is $N\phi \omega$ is a measure of the angular velocity
- Pulse shaping signal conditioner can be used to transform the output into a sequence of pulses which can be counted by a counter
- The number counted in a particular time interval being a measure of the angular velocity

Tacho-generator (Tachometer):

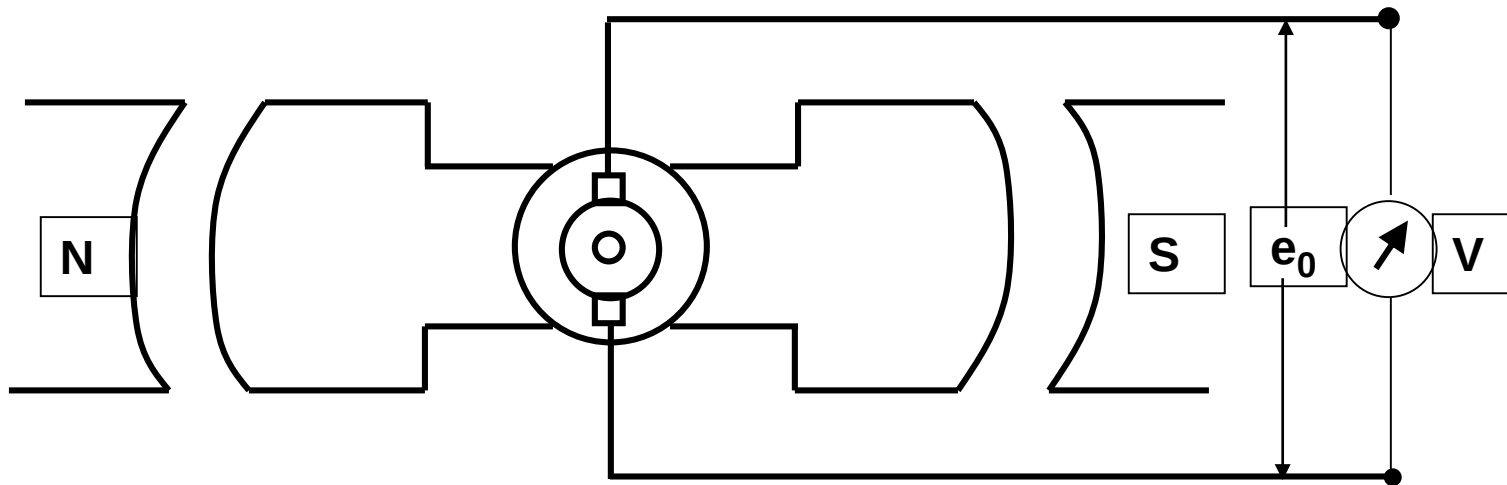


Figure 1) D.C. Tacho- generator

Application:

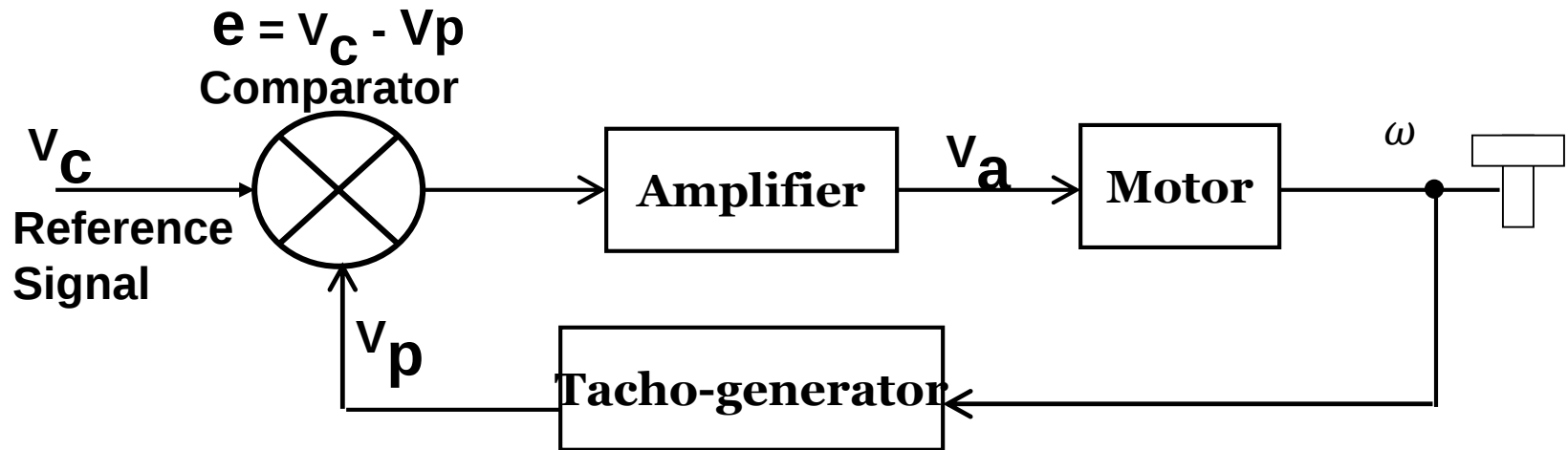


Figure: Speed Measurement system

$$V_p = K_p \cdot \omega$$

$V_p \rightarrow$ Feedback voltage

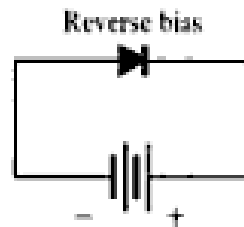
$K_p \rightarrow$ Tachometer const.

$\omega \rightarrow$ Angular speed of rotor

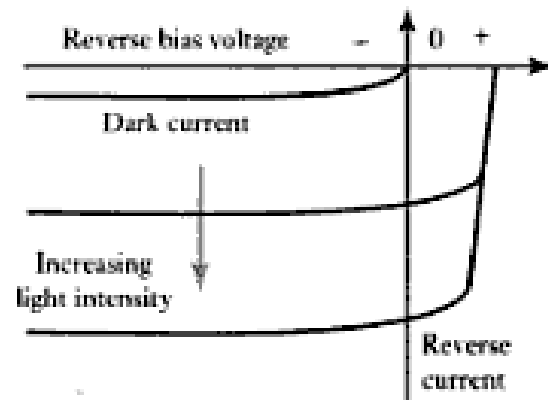
Light Sensor

- Photodiodes are pn junction diodes connected in reverse bias condition. The reverse bias junction has high resistance
- Incoming light can excite electrons being bound in the crystal lattice and will generate free electron hole pairs in the junction. As a consequence the resistance drops and current increases being proportional to the intensity of radiation or light.

Photodiode.



(a)



(b)

Light Sensor - Phototransistor

- ✓ Phototransistor has three layer such as either pnp or npn layers.
- ✓ Light falls on the collector base junction reducing the junction resistance being rise to collector current sufficient enough for detection.
- ✓ Sensitivity is defined as the ratio of the output voltage to the incident energy.
- ✓ The capability to convert light energy to electrical energy is expressed as quantum efficiency.

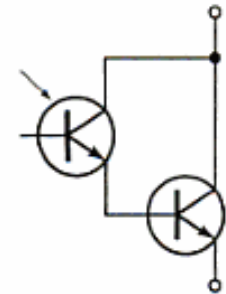
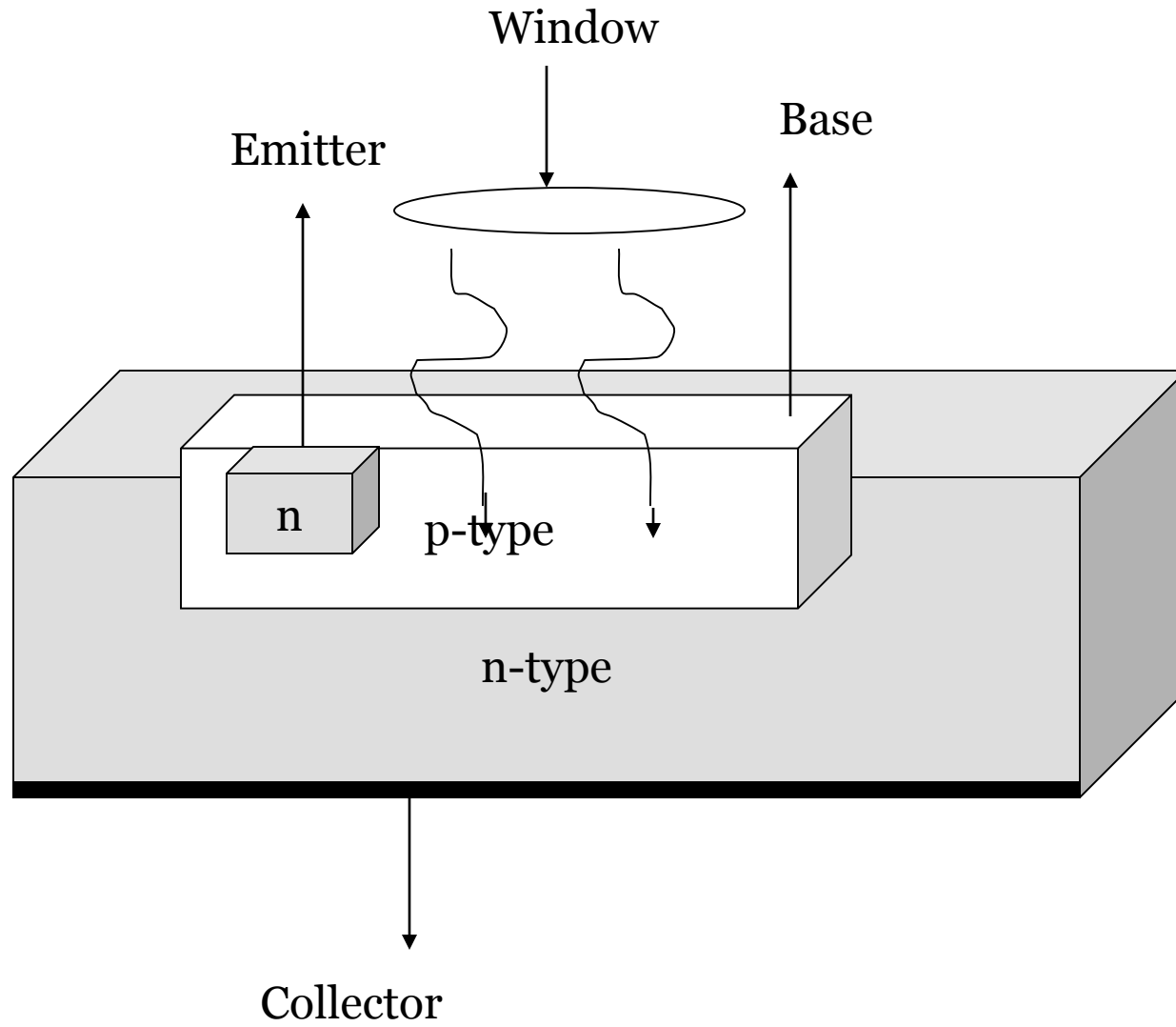


Figure 2.53 Photo Darlington.



Proximity Switches

Proximity switches

A sensing device which gives output to a **proximity sensor** when the object is present.

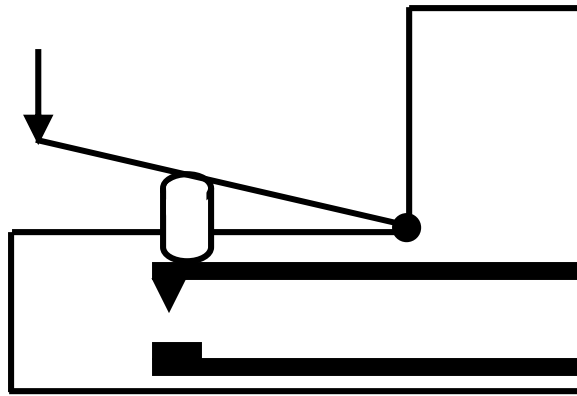
Micro switch:

Small electrical switch which needs small physical contact

Reed switch:

It is a non contact proximity switch

Micro switch



- Button to operate
- Switch contacts
- Lever

Figure 1): Lever operated

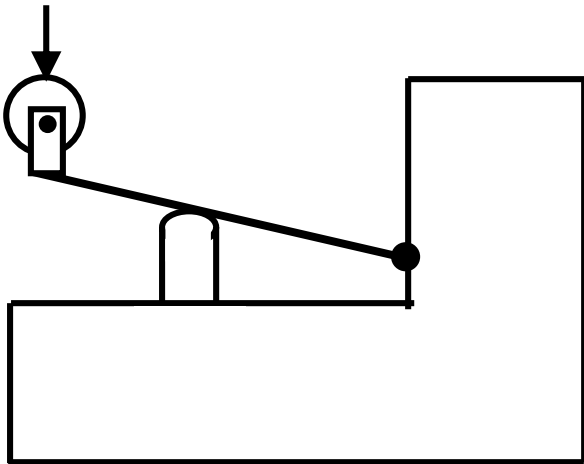


Figure 2): Roller operated

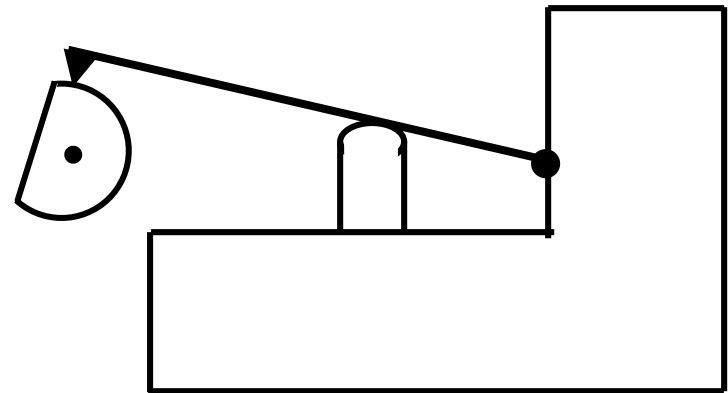


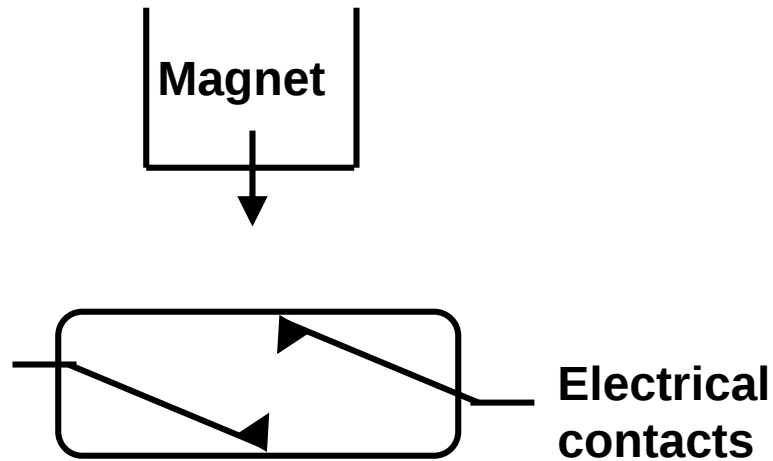
Figure 3): Cam operated

Non contact type Switches

This type of proximity switches used when :

- ♦ The object being detected is too small, too soft or too light weight to operate a mechanical switch.
- ♦ Rapid response and high switching rates are required, as in counting or ejection control applications.
- ♦ An object has to be sensed through non-metallic barriers such as glass, plastic and paper cartons.
- ♦ Hostile environments demand improved sealing properties, preventing proper operation of mechanical switches.
- ♦ Long life and reliable service are required.

Reed switch

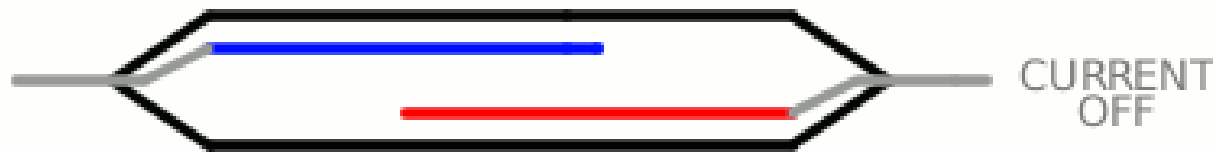


- In a reed switch, the two contacts are made from magnetic material and housed inside a thin glass envelope.
- bring a magnet up to a reed switch, it magnetizes the contacts in opposite ways so they attract and spring together and a current flows through them.
- Take the magnet away and the contacts—made from fairly stiff and springy metal—push apart again and return back to their original positions.

1. "Normally open" reed switch

Magnetic
contact

Magnetic
contact



2. Switch closes when magnet is near

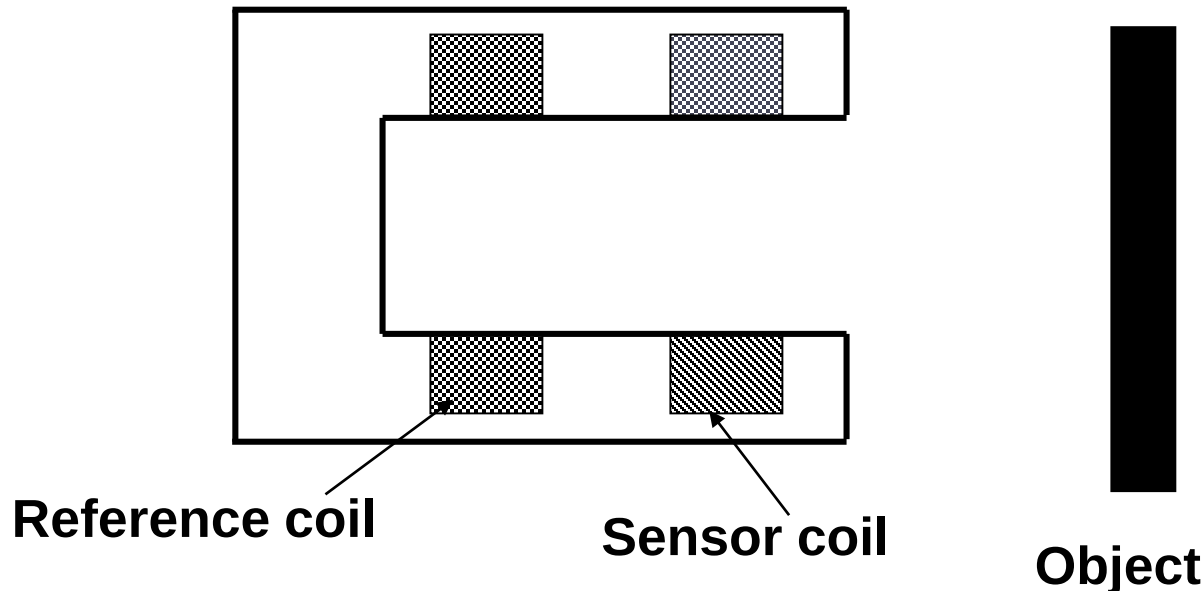
Magnetic
contact

Magnetic
contact



Eddy current proximity sensors

- ✓ Consists two coil
 - Active /sensor coil : which is influenced by the presence of a conducting material.
 - Reference/balance coil : serves to complete a bridge circuit.
- ✓ The coil is supplied with alternating current which produces an alternating magnetic field.



Eddy current proximity sensors

- If there is **conducting object** in close proximity to this magnetic flux lines the **eddy currents** are induced in it.
- As the conducting object comes closer to the sensor the eddy current become stronger which **changes the impedance of the sensor coil** and causes a **bridge unbalance** related to object position.
- This impedance change of the coil results in **changing the amplitude** of the alternating current.
- At some **preset level this change** can be used to **trigger a switch**.

- **Used for detection of non-magnetic but conductive materials**

Advantage

- Relatively inexpensive
- Small in size
- High reliability
- High sensitivity to small displacements

Ultrasonic Sensors

- ✓ Basic principle of operation:
 - ❖ Emit a quick burst of ultrasound (50kHz), (human hearing: 20Hz to 20kHz)
 - ❖ Measure the elapsed time until the receiver indicates that an echo is detected.
 - ❖ Determine how far away the nearest object is from the sensor

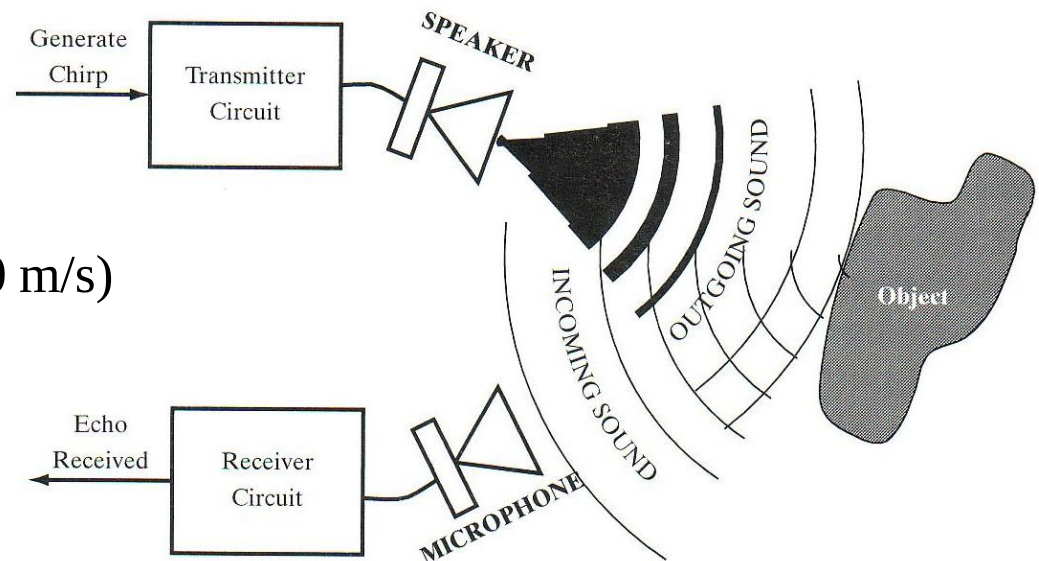
$$\blacksquare D = v * t$$

D = round-trip distance

v = speed of propagation(340 m/s)

t = elapsed time

Bat, dolphin, ...

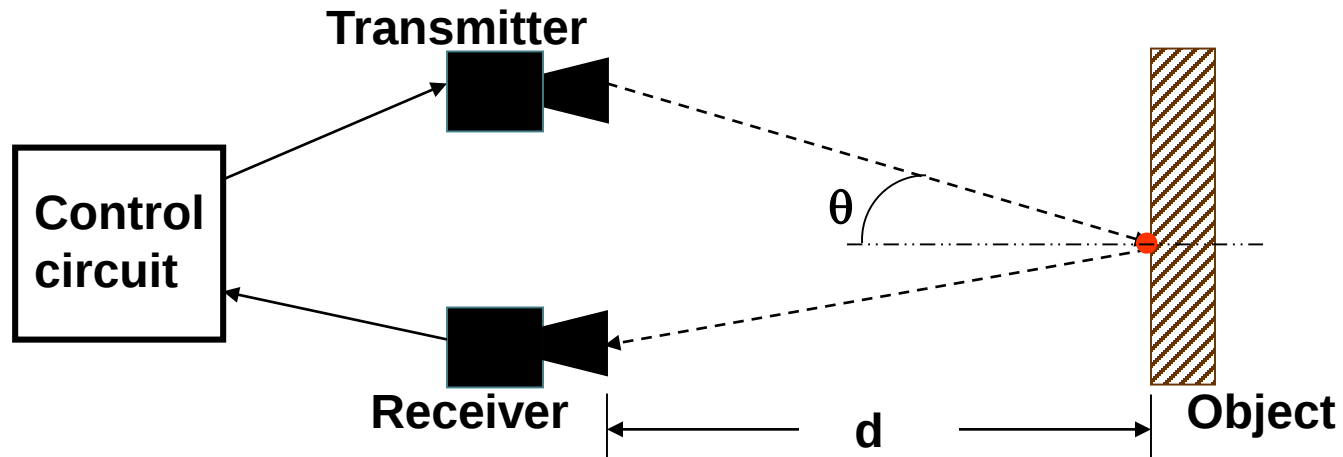


Detection system is based on 2 techniques:

- **Pulse technique:** The detector measures the time, dt , spent between the transmitter/receiver and the object
- **Doppler technique:** The frequency of the received ultrasonic signal changes in relation to the emitted frequency depending on the velocity ' v ' of the object.
- If the object is approaching the detector, then the frequency of the signal received increases in relation to the emitted frequency.
- It is reduced when the object is moving away from the detector.

- The **penetrative quality** of ultrasonic waves makes them useful for noninvasive measurements in environments that are **radioactive, explosive or difficult to access**
- Used for sensing distance, level and speed and for medical imaging devices, dimensional gauging and robotic application.

Ultrasonic distance sensor

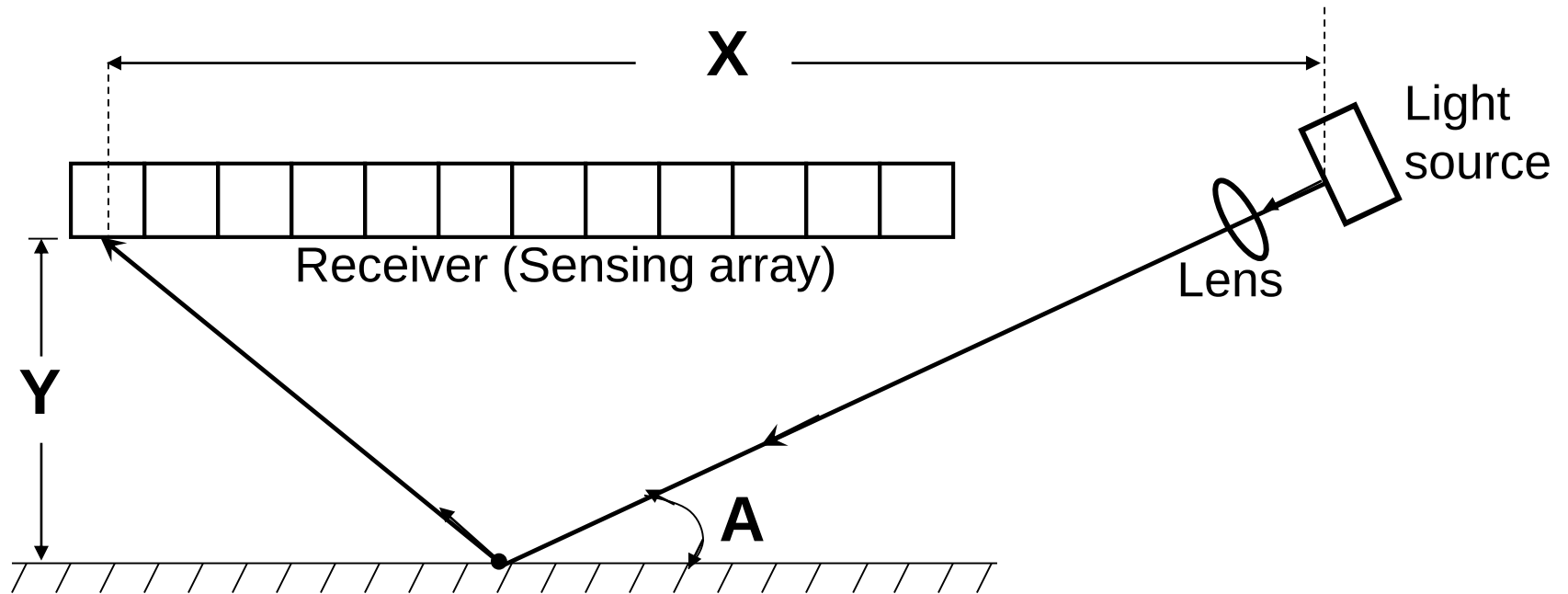


Ultrasonic distance sensing

Distance,

$$d = \frac{v t \cos \theta}{2}$$

Optical proximity sensor:



Scheme for a proximity sensor using reflected light against a sensor array

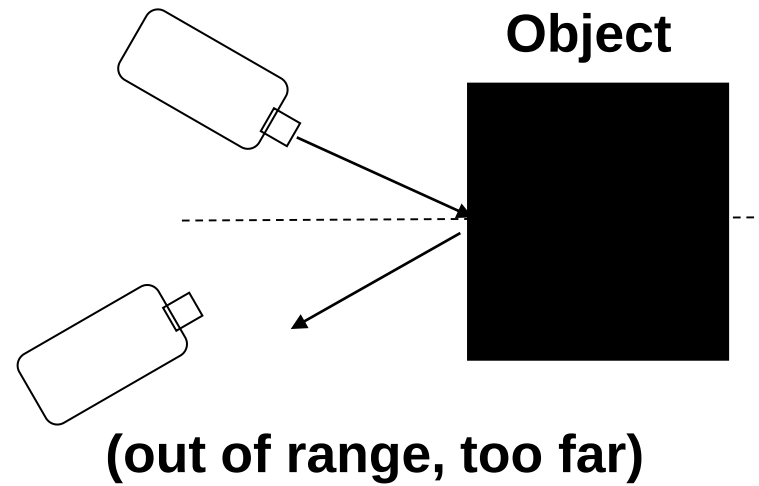
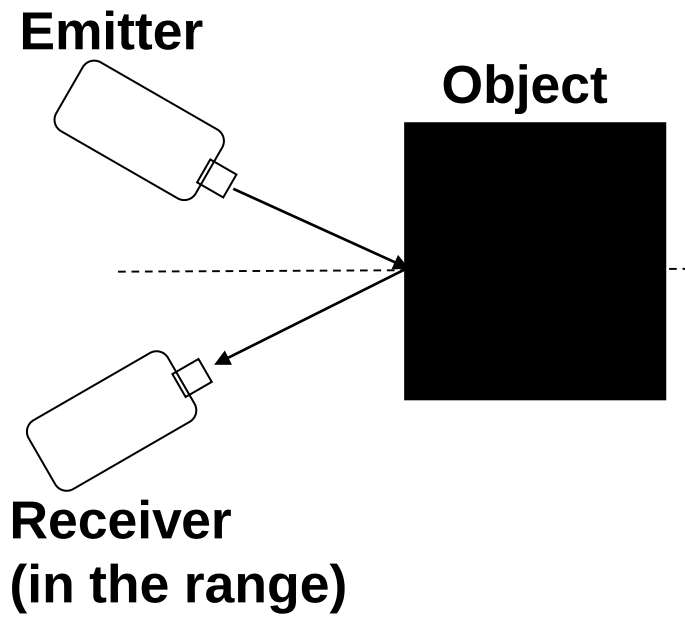
Distance between the object & sensor,

$$Y = 0.5X \tan (A)$$

$Y \rightarrow$ Dist. of the object from sensor

$X \rightarrow$ dist. between source & reflected beam

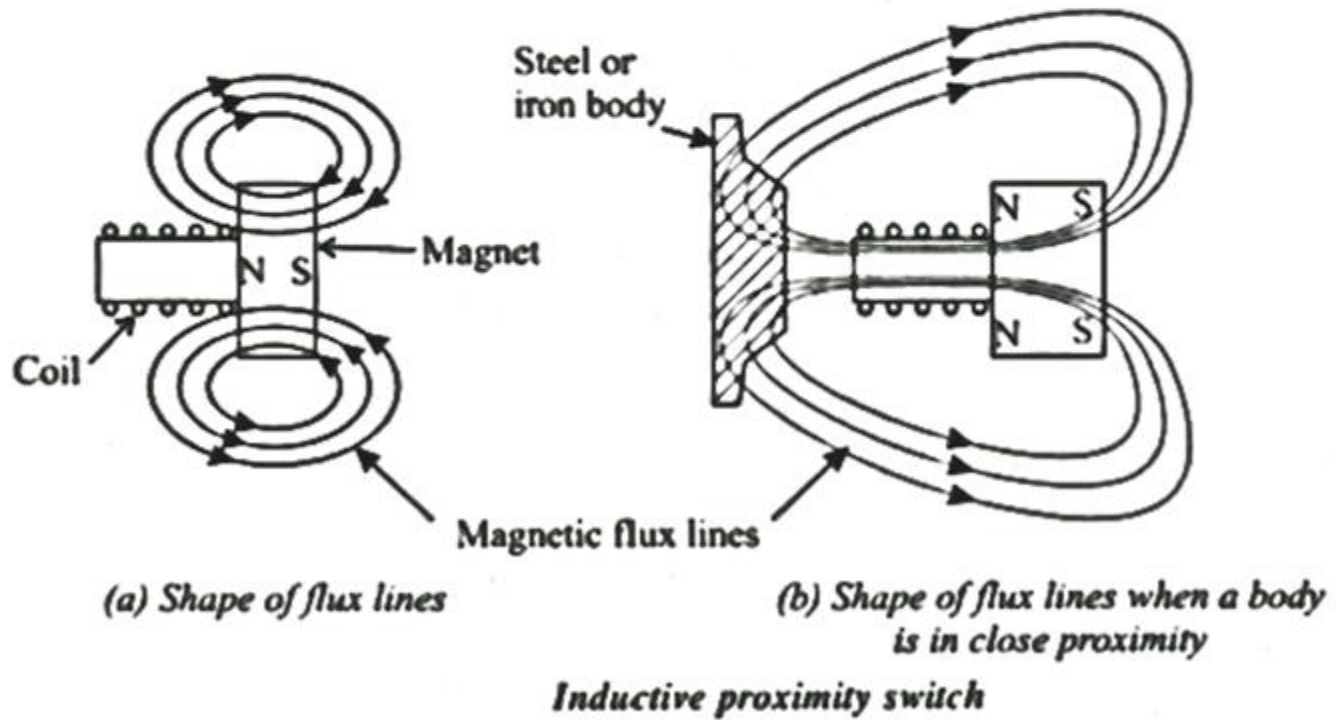
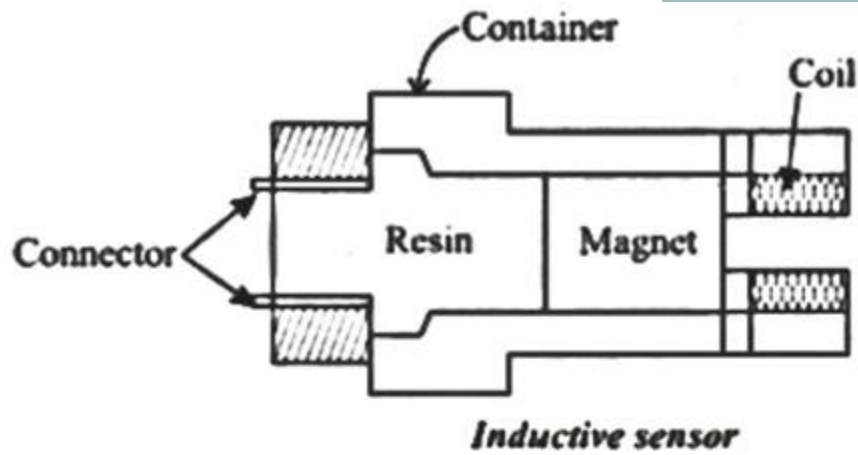
$A \rightarrow$ Angle between object & sensor



Optical proximity sensor

Inductive proximity switch

- Consists of a coil wound round a core, next to a permanent magnet.
- When the end of the coil is close to metal object its inductance changes
- This change can be monitored by its effect on a resonant circuit and the change used to trigger a switch
- **It can only be used for the detection of metal objects and is best with ferrous metals**



Flow measurement - Introduction

- Flow sensing for measurement and control is one of the most critical areas in the modern industrial process industry
- The continuous manufacturing process relies on accurate monitoring and inspections involving raw materials, products and waste throughout the process.
- Conventional devices for flow sensing employ
 - Orifice plate
 - Nozzle
 - Venturi tube

- The **probe introduces a disturbance** in the measured quantity by modifying the flow that would exist in the absence of the probe.
- The measurements also are prone to **errors due to errors non alignment of the probe** with respect to the flow direction.

FLOW SENSORS

Flow sensor is an electronic device which **measures flow** irrespective of nature of the fluid and **transforms it in to a signal.**

Ultrasonic transducer:

Measures fluid velocity by passing high-frequency sound waves through the fluid.

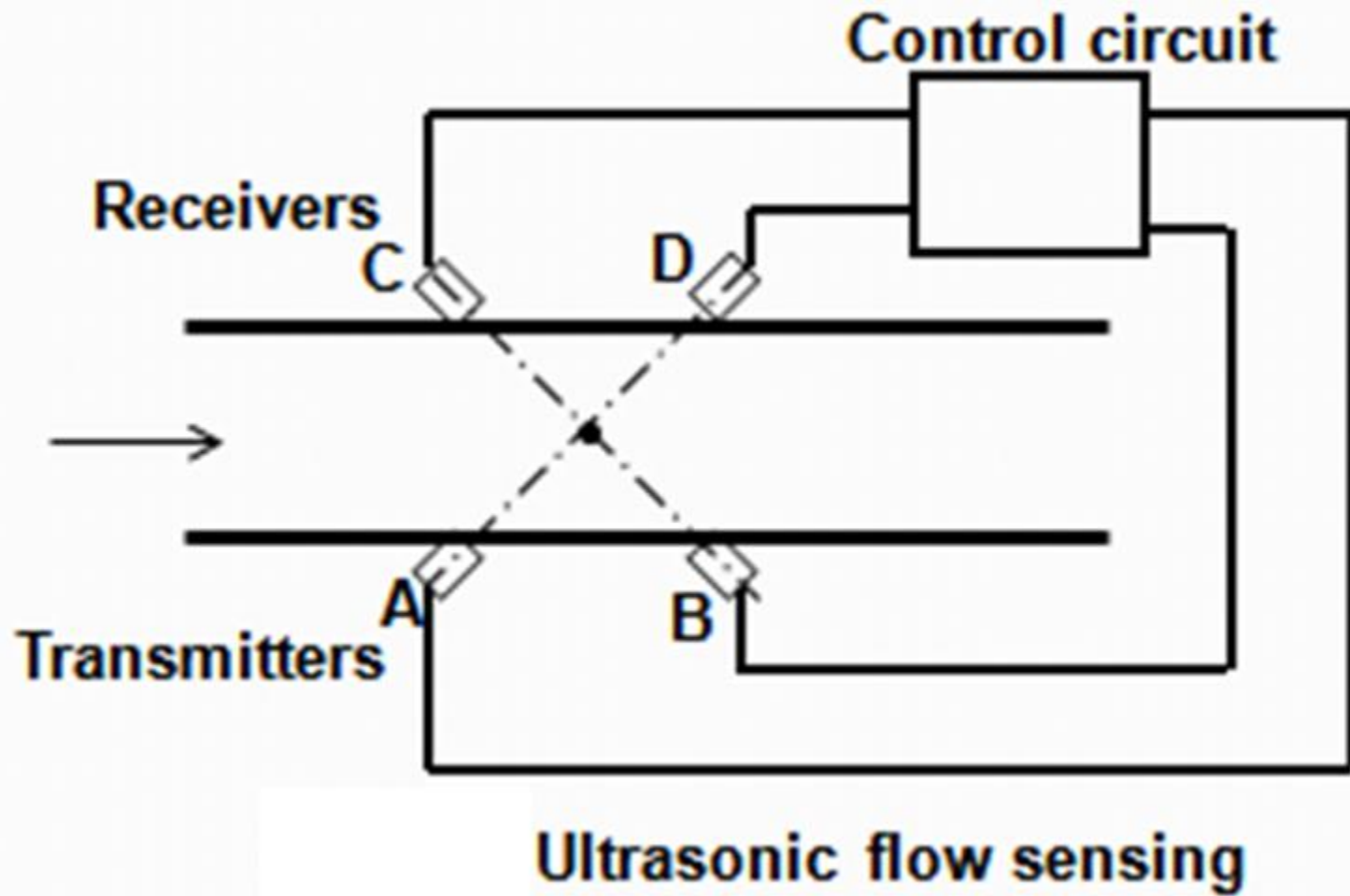
Laser Doppler Anemometer:

Measures instantaneous flow velocity of fluids in a transparent channel.

Ultrasonic sensor

- Ultrasonic flow meters measure fluid velocity by passing **high-frequency sound waves** through the fluid.
- Sometimes called **transit time flow** meters, they operate by measuring transmission time difference of an ultrasonic beam passed through a homogeneous fluid contained in a pipe both an upstream and a downstream location.

Ultrasonic transducer:



- The transducer consists of transmitter and receiver pairs.
- One pair A and B act as transmitters and the other pair C and D act as receivers
- If a sound pulse is transmitted from transmitter B to receiver C the transit time is calculated as

$$t_{BC} = \frac{d}{[\sin\alpha(C - V\cos\alpha)]}$$

—————→ 1

- If the pulse is transmitted from transmitter A to receiver D, the transit time is

$$t_{AD} = \frac{d}{[\sin\alpha(C + V\cos\alpha)]} \longrightarrow 2$$

Where

- d = diameter of the tube, m
- V = velocity of the fluid flow, m/sec
- α = angle between the path of sound and pipe wall
- C = sound velocity in the fluid, m/sec
- (Assume $V \ll C$)

- The transit time difference Δt is difference between 2 eqn. it is proportional to flow velocity and fluid flow and can be used as an input to the computer
- By measuring the transit times at both upstream and downstream locations the fluid velocity can be expressed independently of the sound velocity in the fluid
- Since the measurement is independent of the velocity of sound through the fluid the effects of pressure and temperature are avoided.

$$\frac{t_{BC} - t_{AD}}{t_{BC}t_{AD}} = \frac{2V \sin \alpha \cos \alpha}{d}$$



The Ultrasonic Flow Measuring Principle.flv

Laser Doppler Anemometer

- A laser beam is focused at a point in the fluid where the velocity is to be measured.
- The laser beam is scattered by the small particles flowing in the liquid. Due to viscous effects, the small particles move at the same velocity as the fluid, So the measurement of the particle velocity is the same as the fluid velocity.
- Signal processing of the photo detector output produces the magnitude of the Doppler frequency shift, which is directly proportional to the instantaneous 'velocity of flow.

Laser Doppler Anemometer:

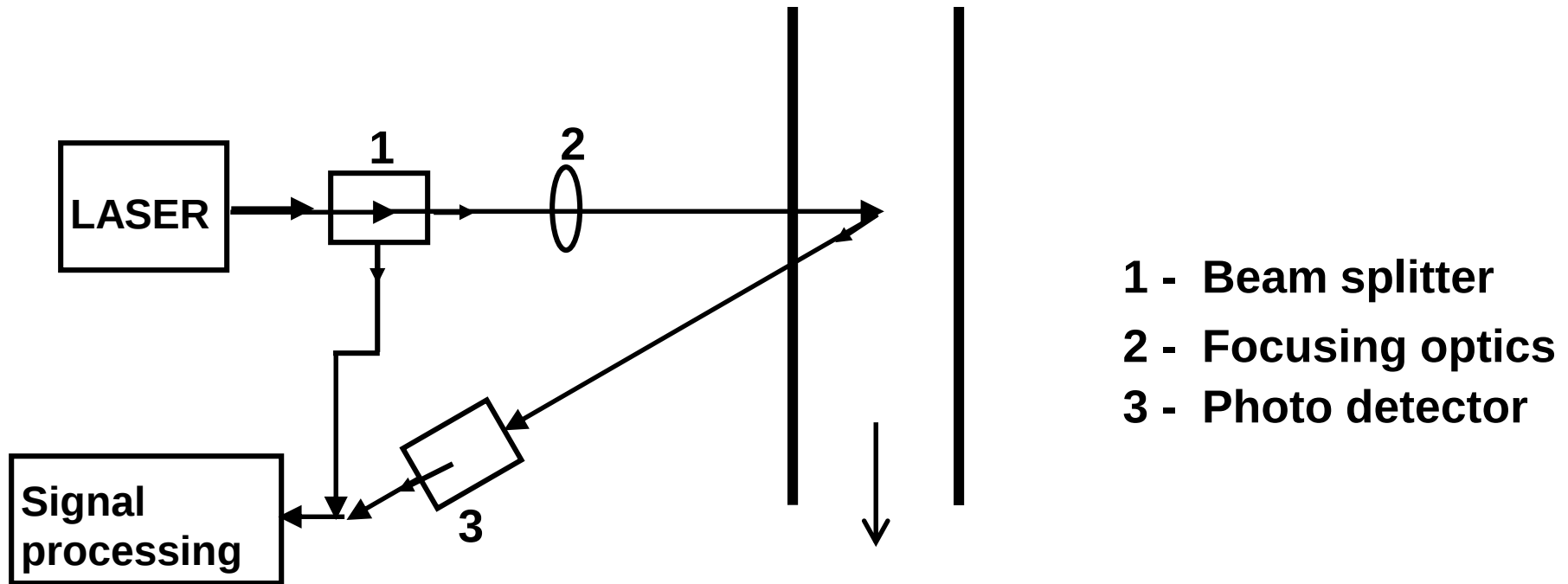


Figure: Laser Doppler anemometer

Frequency shift,

$$\Delta f = \frac{2V \cos \theta}{C} f_0$$

$V \rightarrow$ particle Velocity

$\theta \rightarrow$ Angle between laser beam and the particle

$C \rightarrow$ speed of light

$f_0 \rightarrow$ frequency of the beam

Machine Vision System

- Machine vision can be defined as the acquisition of image data, followed by the processing and interpretation of these data by computer for some useful application.
- Vision systems are classified as being either 2-D or 3-D.
- The operation of a machine vision system can be divided into the following three functions:
 - (1) image acquisition and digitization.
 - (2) Image processing and analysis, and
 - (3) interpretation.

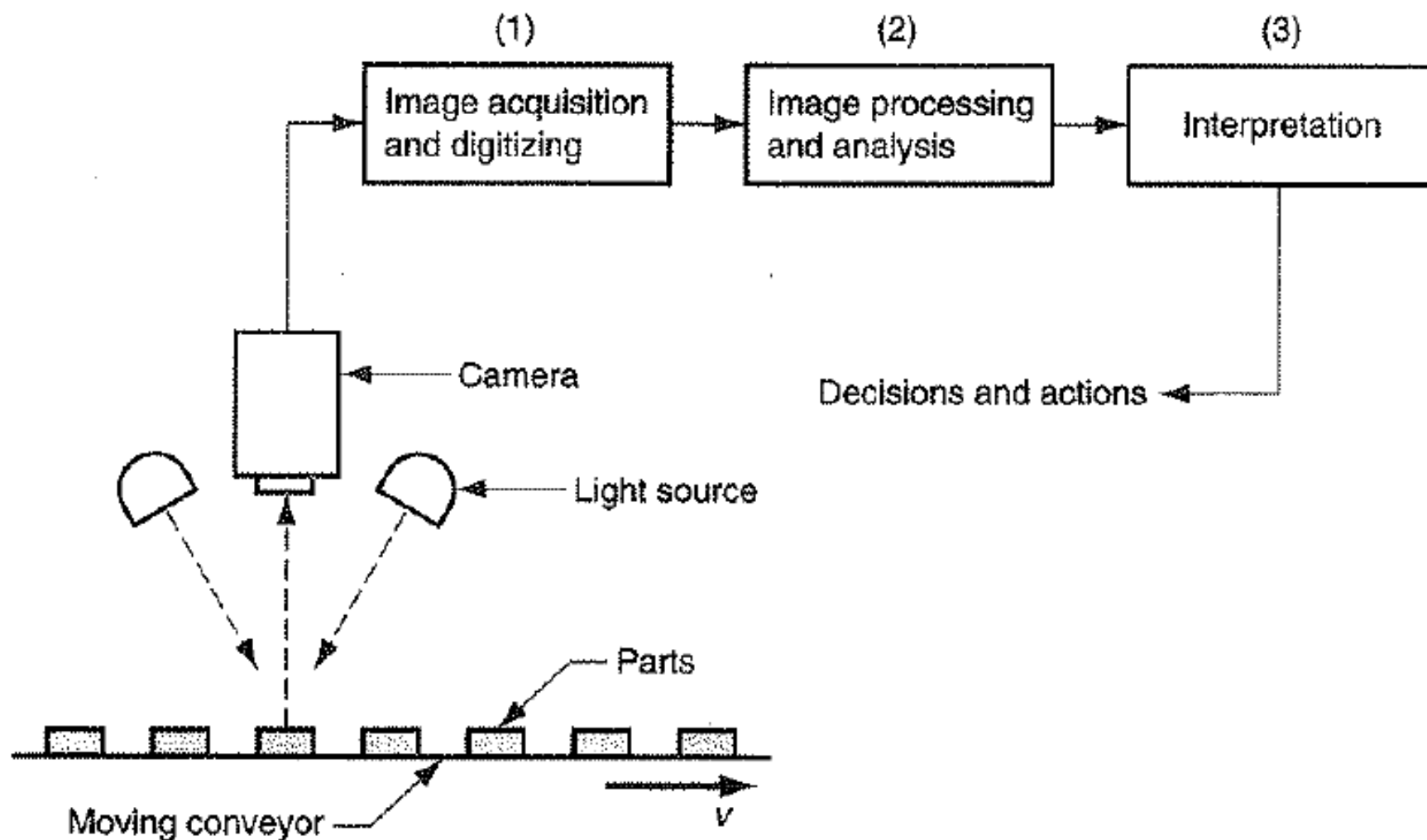
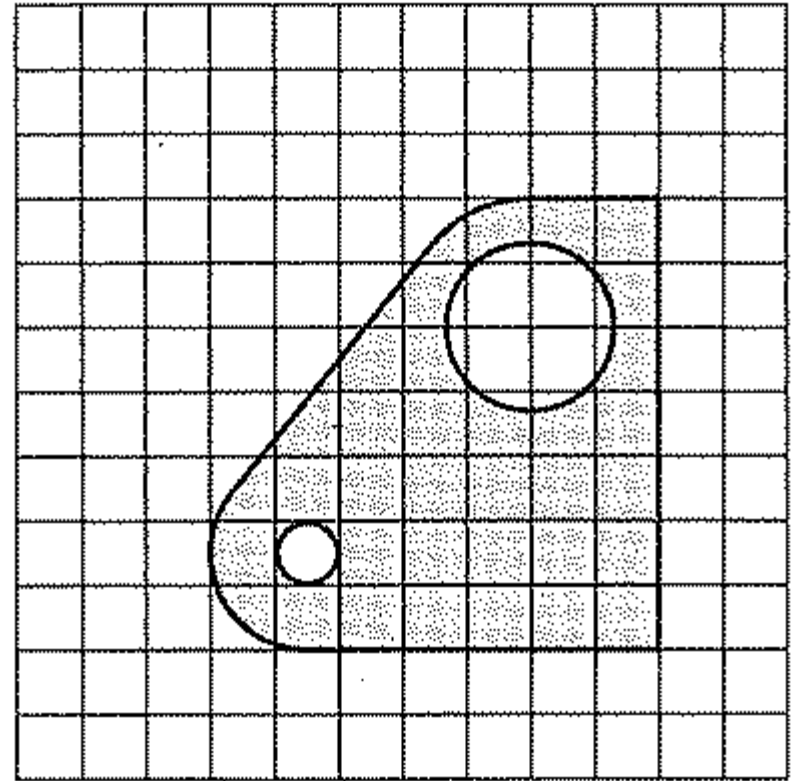
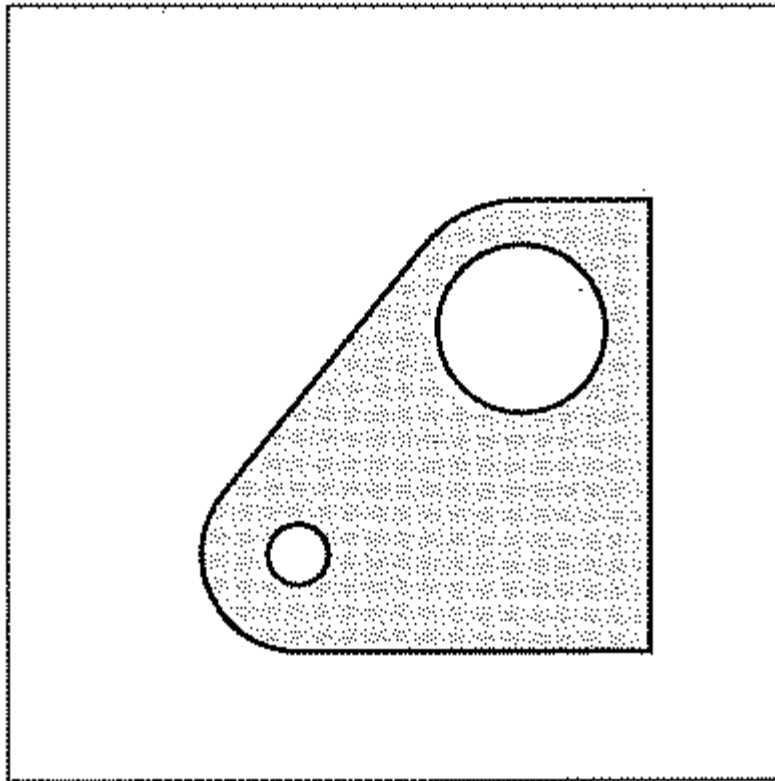


Image Acquisition and Digitization

- Image acquisition and digitization is accomplished using a video camera and a digitizing system to store the image data for subsequent analysis.
- The camera is focused on the subject of interest and an Image is obtained by dividing the viewing area into a matrix of discrete picture elements (called pixels) in which each element has a value that is proportional to the light intensity of that portion of the scene.
- The intensity value for each pixel is converted into its equivalent digital value by an ADC



the likely Image obtained from the simplest type of vision system called a binary-vision system

- In **binary** vision the light intensity of each pixel is ultimately reduced to either of two values white or black depending on whether the light intensity exceeds a given threshold level.
- A most sophisticated vision system is capable of distinguishing and storing different shades of Gray in the image. This is called a Gray-scale system.

- ✓ Each set of digitized pixel values is referred to as a frame;
- ✓ Each frame is stored in a computer memory device called a frame buffer.
- ✓ The process of reading all the pixel values in a frame is performed with a frequency of 30 times per second

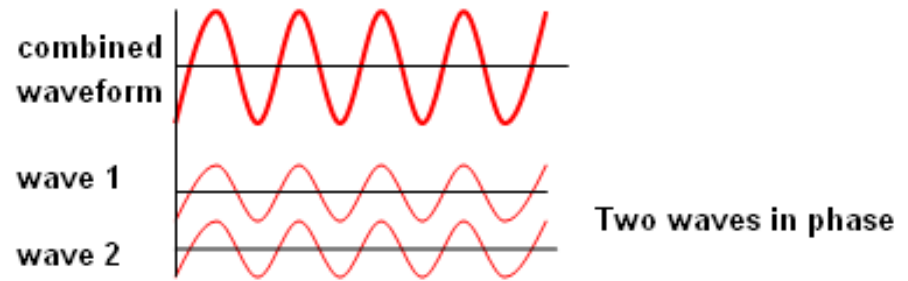
- Types of Cameras: Two types of cameras are used in machine vision applications:
- **Vidicon cameras** (the type used for television) - operate by focusing the image onto a photoconductive surface and scanning the surface with an electron beam to obtain the relative pixel values
- **Solid-state cameras** - operate by focusing the image onto a 2-D array of very small, finely spaced photosensitive elements. An electrical charge is generated by each element according to the intensity of light striking the element

- *Illumination*: Another important aspect of machine vision is illumination. The scene viewed by the vision camera must be well illuminated, and the illumination must be constant over time.

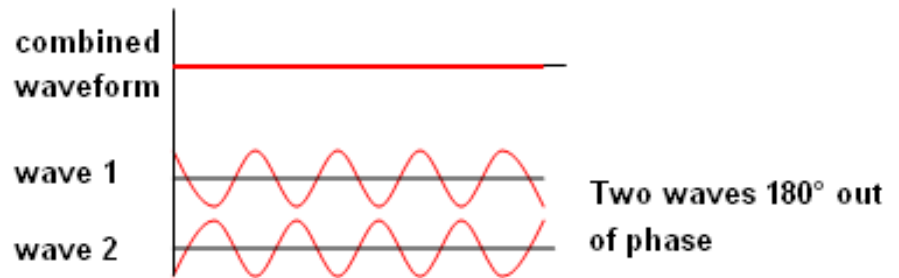
Laser Interferometer

- Interferometry = “interference” + “measurement”
- Basic application: hi-res measurement of distances
- Basic principle: superposition of light waves

Constructive interference



Destructive interference



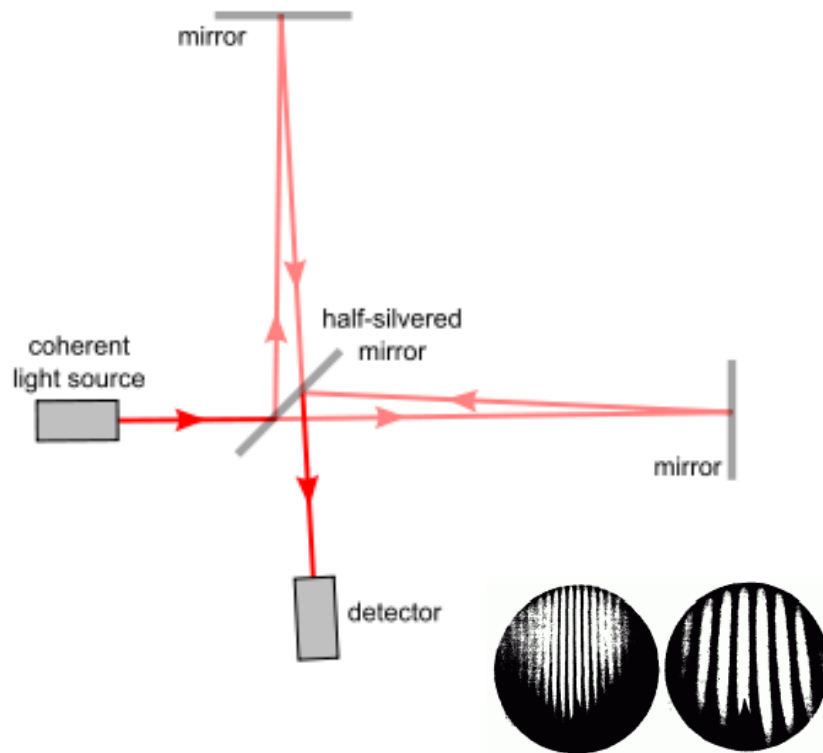
Laser interferometer

- *Optoelectronic instrument that measures distance in terms of the wavelength of the light by examining the phase relationship between a reference beam and a laser beam reflected from a target object.*
- *Laser produces collimated light rays of single frequency present with phase coherence.*
- *The laser beam with an optical arrangement produces the reference beam*
- *A part of the reference beam is transmitted to the target and a part is sent to the interferometer*
- *The rays reflected from the target are recombined at the interferometer*
- *The phase difference between the reference beam from the source and the reflected beam from the target is equal to the extra length traversed by the beam.*
- *The digitized information from the difference between the two signals provides the distance information*

- Used **for precision motion measurement** and for **checking the linearity of precision machine tool slides** and the **perpendicularity of machine tool structures** mainly during **installation** of machine tools

What is a Laser Interferometer?

- The Michelson Interferometer

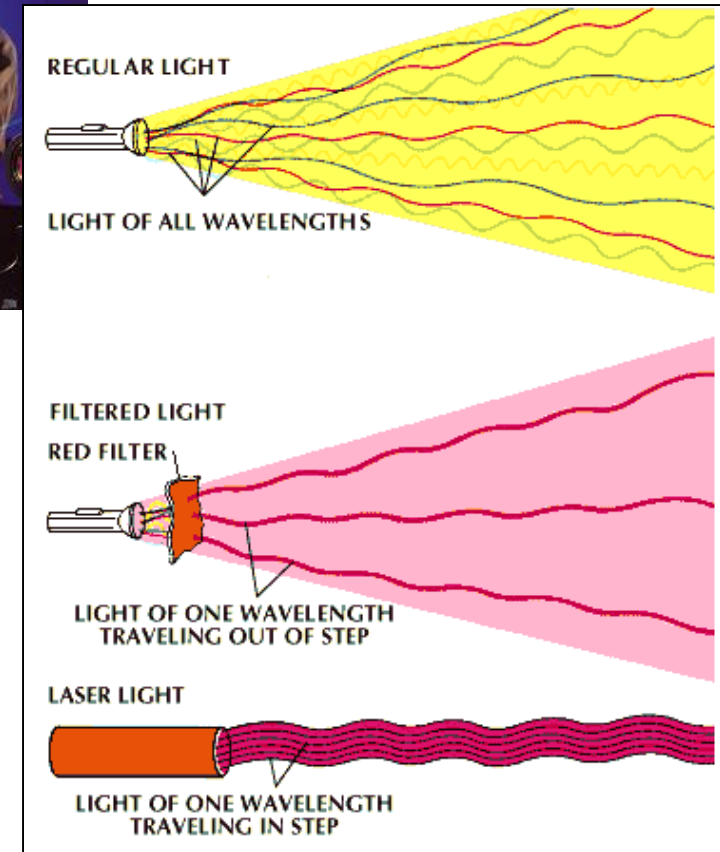


- Difference in path length results in phase difference
- Phase difference causes interference
- Interference determined by analysis of fringe patterns

What is a Laser Interferometer?

Why “lasers” ?

- High coherence
- Collimated
- Predictable
 - Frequency known

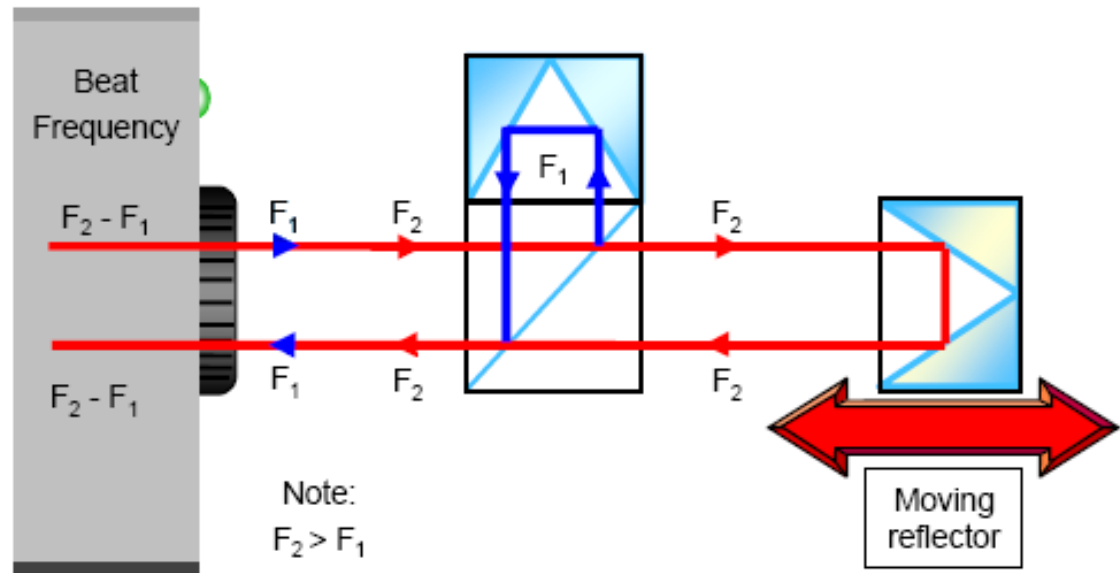


Types of Laser Interferometers

- Homodyne detection (standard interferometry)
 - DC output signal from photodiode related to intensity of light from interference
 - Both beams have same frequency
- Heterodyne detection
 - One beam is frequency modulated prior to detection
 - Phase determined by signal analysis

How Do They Work?

- Homodyne – already discussed (Michelson interferometer)
- Heterodyne
 - Dual frequency, polarized laser source
 - Polarizing beam splitter



Range Finder



- Time of Flight
- The measured pulses typically come from ultrasonic, RF and optical energy sources.
 - $D = v * t$
 - D = round-trip distance
 - v = speed of wave propagation
 - t = elapsed time
- Sound = 0.3 meters/msec
- RF/light = 0.3 meters / ns (Very difficult to measure short distances 1-100 meters)

Ultrasonic sensor

- Consists of a transmitter, a receiver and a processing unit
- The transducer produces ultrasonic waves normally in the frequency in the range of 30KHz to 100Khz.
- In proximity sensing applications the ultrasonic beam is projected on the target and time it takes for the beam to echo from the surface is measured. [Sensor transmits a signal and receives the reflected beam]

Ultrasonic Sensors

- Basic principle of operation:
 - Emit a quick burst of ultrasound (50kHz), (human hearing: 20Hz to 20kHz)
 - Measure the elapsed time until the receiver indicates that an echo is detected.
 - Determine how far away the nearest object is from the sensor

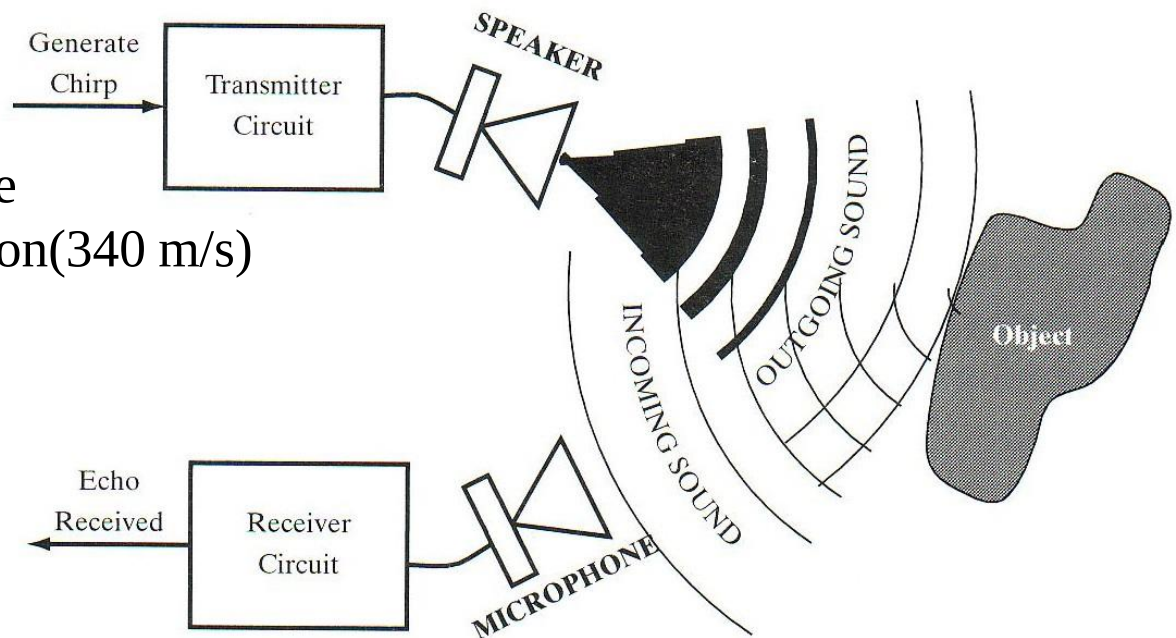
■ $D = v * t$

D = round-trip distance

v = speed of propagation (340 m/s)

t = elapsed time

Bat, dolphin, ...



Detection system is based on 2 techniques:

- Pulse technique: The detector measures the time, dt , spent between the transmitter/receiver and the object
- Doppler technique: The frequency of the received ultrasonic signal changes in relation to the emitted frequency depending on the velocity ' v ' of the object.
- If the object is approaching the detector, then the frequency of the signal received increases in relation to the emitted frequency.
- It is reduced when the object is moving away from the detector.

- The penetrative quality of ultrasonic waves makes them useful for noninvasive measurements in environments that are radioactive, explosive or difficult to access
- Used for sensing distance, level and speed and for medical imaging devices, dimensional gauging and robotic application.

Noise Issues

