MECHATRONICS – 15ME54T

Lecture Notes / PPT

UNIT I

MECHATRONICS ,SENSORS AND TRANSDUCERS

SYLLABUS

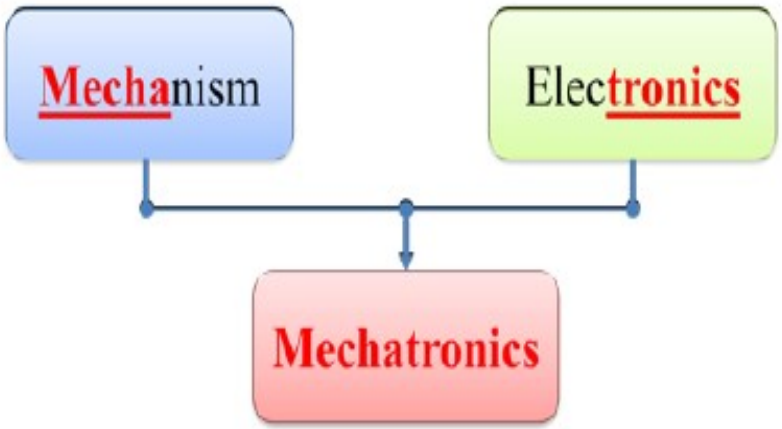
Introduction to Mechatronics, Sensors & Transducers

- Introduction to Mechatronics Systems - Measurement Systems - Control Systems -Sensors and Transducers - Performance Terminology - Sensors for-Displacement, Velocity, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature, Light Sensors, Selection of Sensors.

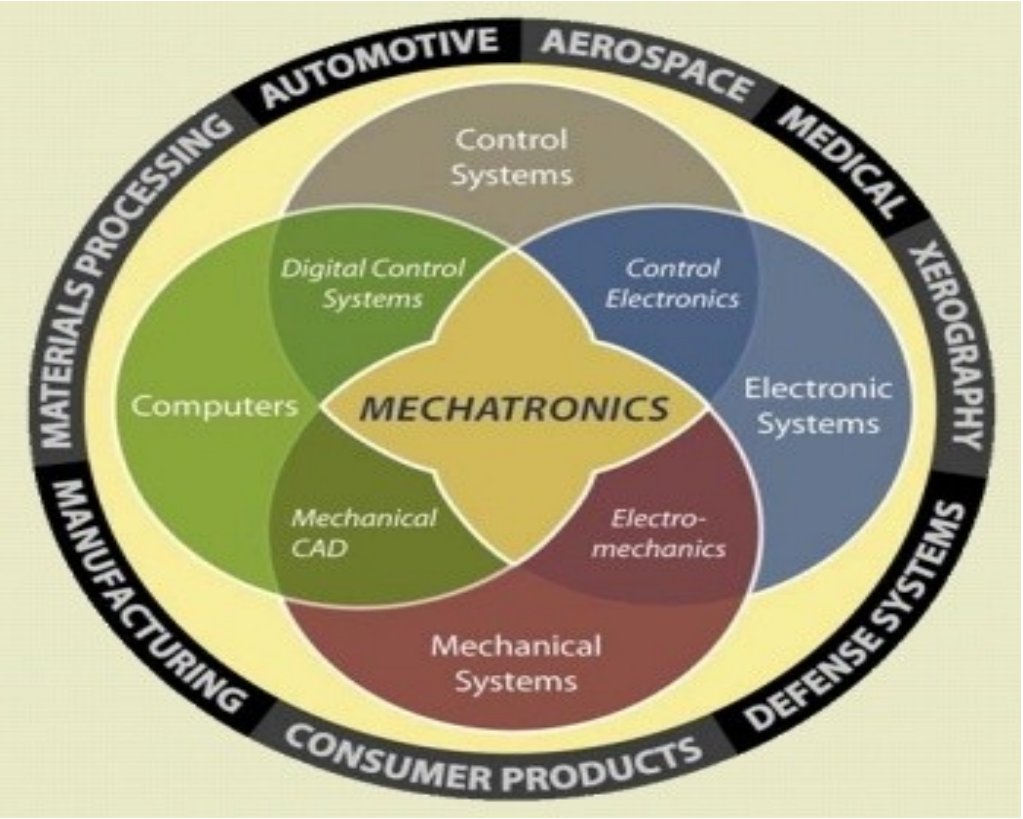
WHAT IS MECHATRONICS?

- The word “mechatronics” was first coined by Mr. Tetsuro Moria, a senior engineer of a Japanese company, Yaskawa, in 1969.

- Mechatronics is the synergistic combination of mechanical engineering (“mecha” for mechanisms), electronic engineering (“tronics” for electronics), and software engineering.



MECHATRONICS SYSTEM



- Its also defined as the complete integration of mechanical system with electrical, electronic and computer system into single system.

Advantages and disadvantages Mechatronics

1.The products produced are cost effective and very good quality.

2. High degree of flexibility

3. Greater extent of machine utilization

4. Greater productivity

5. High life expected by proper maintenance.

6. The integration of sensor and control system in a complex system reduces capital expenses.

DISADVANTAGE

1. Higher initial cost of the system.

2.Important to have Knowledge of different engineering fields for design and implementation.

3. Is expenses to incorporate Mechatronics approaches to existing/old systems.

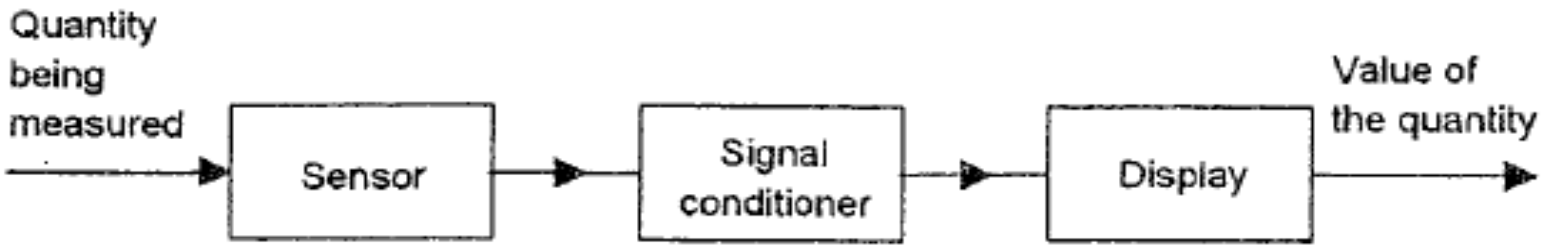
4.Specific problem of various systems will have to be addressed separately and properly.

Application of Mechatronics system?

1. Automotive machines.
2. Fax and photocopier mechanics
3. Dishwashers.
4. Automatic washing machine
5. Air conditioners, elevator controls.
6. Documents scanners
7. IC manufacturing systems.
8. Robotics employed in welding, nuclear inspection, painting etc.,
9. VCRs(Videocassette recorder) and CD Players.

MEASUREMENT SYSTEM

- A group of device/element arranged in rational manner to achieve the act of measurement.
- Generally a measurement system consists of 3 basic elements.
- 1. Sensor/transducer.
- 2. Signal conditioner.
- 3. Display/read out devices.



CONTROL SYSTEM:

- The word control implies to regulate direct or command A controlled system can be used to control its output to to specific value.

  Example: A temperature control unit unit speed control unit,sound control unit.



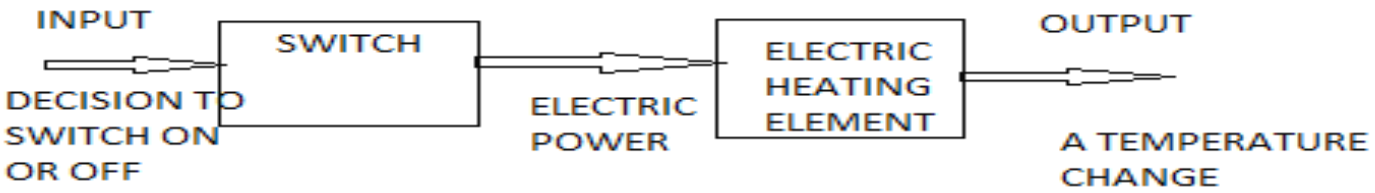
- Control system mainly classifed into two types

1.open loop control system

2. closed loop control system

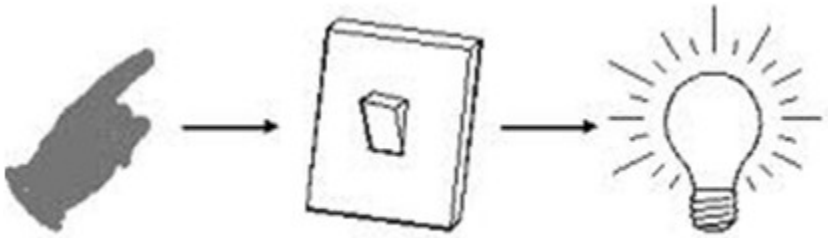
Open loop control system

A control system in which the output is dependent of the input or controlling action is independent of output or change in output is called open loop control system.



Example: On-Off of electric lamp:

An electrical switch serves to control the flow of current in a circuit .the input signal is filling of switch on off and corresponding output signal (bulb) flow electric current in circuit or no flow.



Advantages and Dis-advantages of Open Loop Control

Advantages:

- Simple in construction
- Low cost
- good reliability
- easy maintenance
- less chance of breakdown.

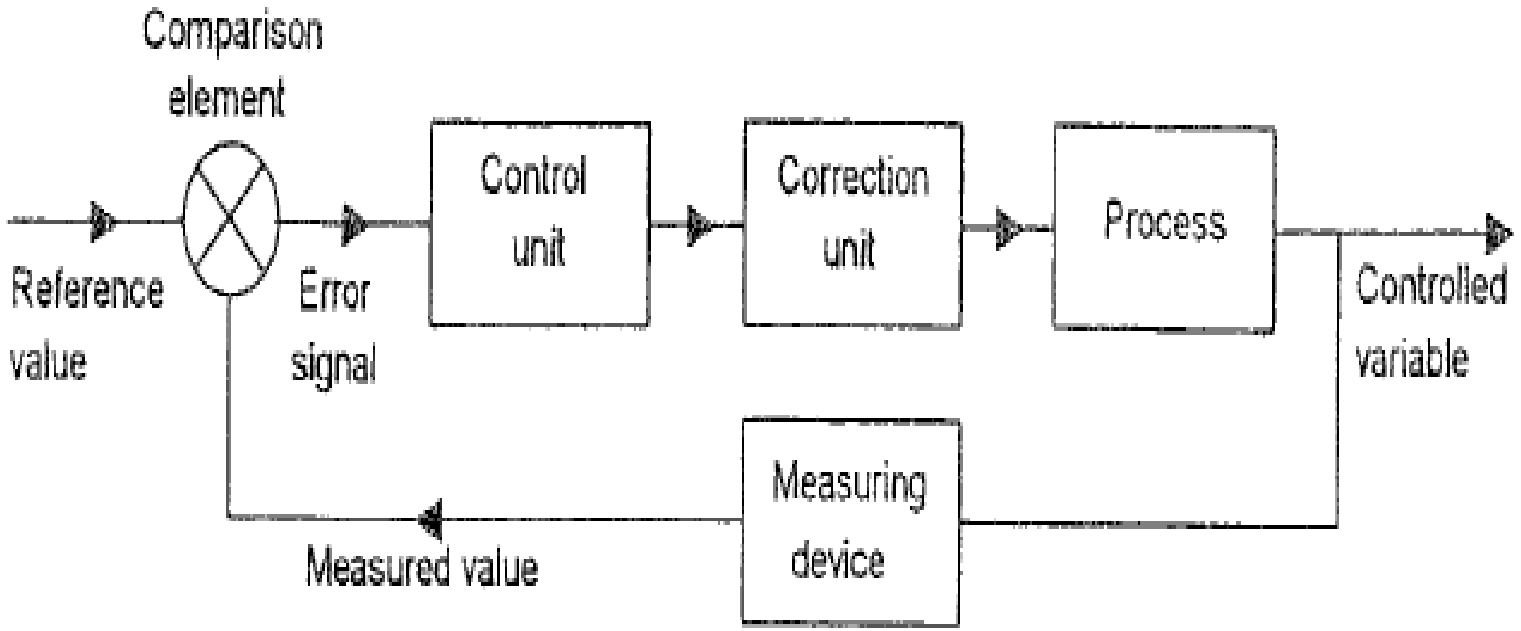
Disadvantages:

- No feedback unit
- often in accurate
- no correction for error.
- The controller never actually knows if the actuator did what it was supposed to do, i.e. it is inaccurate
- Unable to sense the environmental changes or disturbances

Closed loop control system

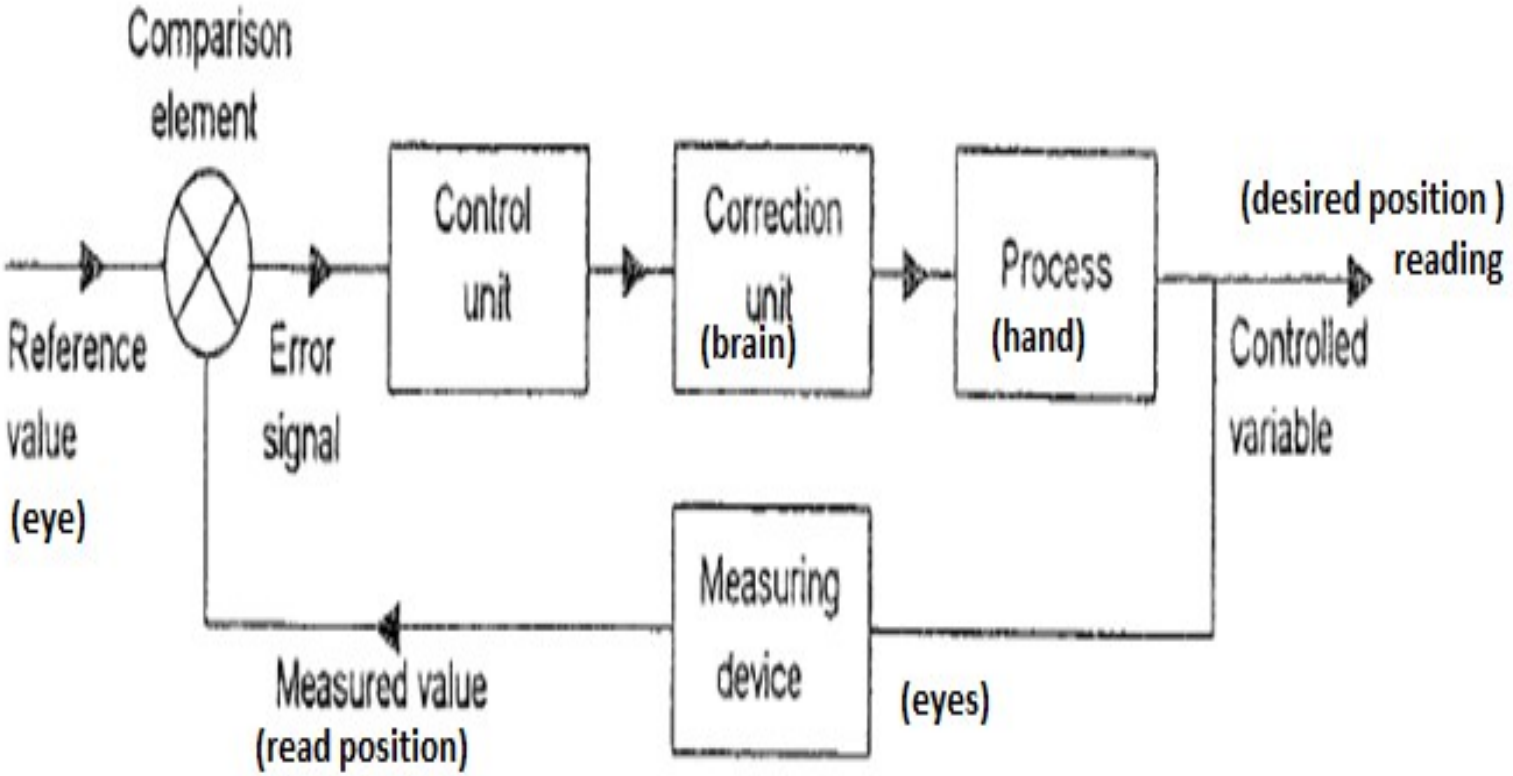
In the closed loop system input is dependant on the output of the system. it has feedback elements. gives the required value.

Basic element of closed loop system



Example of CLCS

- HAND REACHING ON COMPONENT :



Advantages and Dis-advantages of Closed Loop Control

Advantages:

- High system Accurate, since the controller modifies and manipulates the actuating signal such that the error in the system will be zero.
- Self-correcting,because always compare actual value with required value
- Senses the environmental changes, and disturbances in the system.

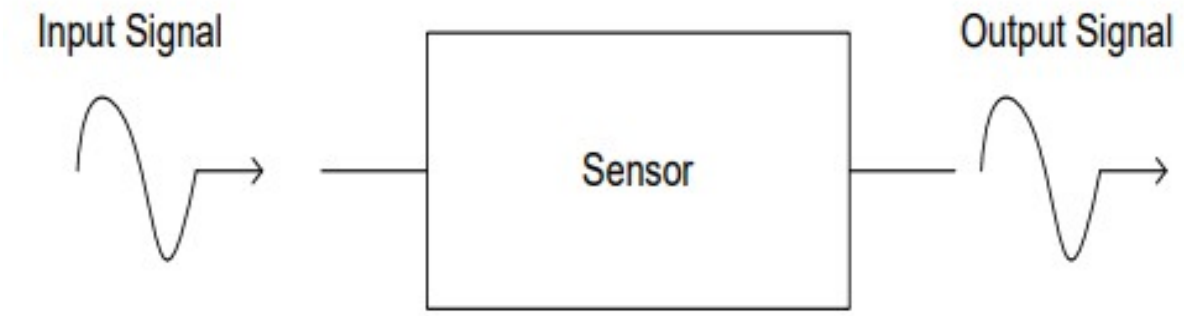
Disadvantages:

- Complicated to design
- Costly
- Instable, since due to feedback , system tries to correct the error.

Sensors and Transducer

Sensor

"A device which provides a usable output in response to a specified measurand."



Transducer

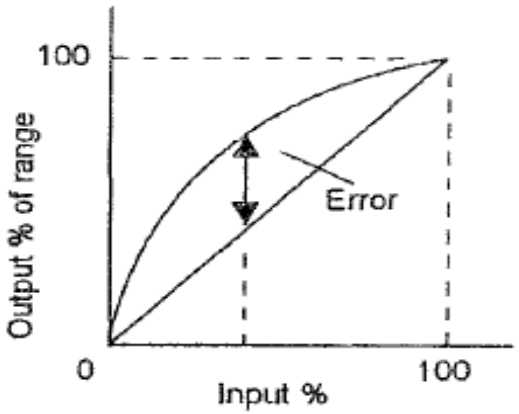
Transducer – a device that converts a primary form of energy into a corresponding signal with a different energy form .

Primary Energy Forms: mechanical, thermal, electromagnetic, optical, chemical, etc.

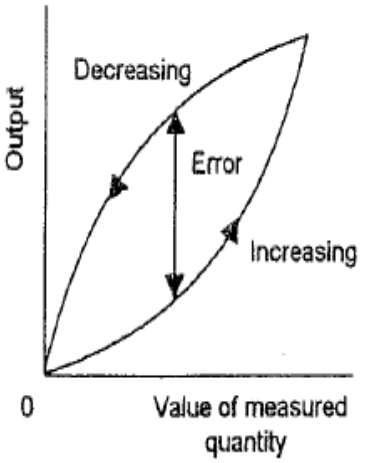
PERFORMANCE TERMINOLOGY

1. **Range :**The range of a sensor indicates the limits between which the input can vary.
2. **Span:** The span is difference between the maximum and minimum values of the input.
3. **Error :**Error is the difference between the result of the measurement and the true value of the quantity being measured.
4. **Accuracy:** The accuracy defines the closeness of the agreement between the actual measurement result and a true value of the measurand. It is often expressed as a percentage of the full range output or full–scale deflection.
5. **Sensitivity:** Sensitivity of a sensor is defined as the ratio of change in output value of a sensor to the per unit change in input value that causes the output change. It has both Linear & nonlinear behavior

6.Nonlinearity :The nonlinearity indicates the maximum deviation of the actual measured curve of a sensor from the ideal curve.



7.Hysteresis: The hysteresis is an error of a sensor, which is defined as the maximum difference in output at any measurement value within the sensor's specified range when approaching the point first with increasing and then with decreasing the input parameter.



8.**Resolution:** The resolution of a sensor is the smallest increment of input that can be detected output signal.

9.Repeatability : Repeatability It specifies the ability of a sensor to give same output for repeated applications of same input value

10. **Stability:** Stability is the ability of a sensor device to give same output when used to measure a constant input over a period of time.

11.**Dead band/time:** The dead band or dead space of a transducer is the range of input values for which there is no output.

12.**output impedance:** when sensor giving an electrical output is interfcaed with an electronic circuit is called output impedance

Basic Principle of Sensor / Transduction



Displacement,
Temperature, Pressure
etc….

Voltage, current,
capacitance

Sensor is a device that when exposed to a physical phenomenon (temperature, displacement, force, etc.) produces a proportional output signal (electrical, mechanical, magnetic, etc.).

Transducer is a device that converts one form of (energy) signal into another form of (energy) signal.

SENSORS

Classification of sensors and transducers applications in manufacturing is as follows.

A. Displacement, position and proximity sensors

- Potentiometer
- Strain-gauged element
- Capacitive element
- Differential transformers
- Eddy current proximity sensors
- Inductive proximity switch
- Optical encoders
- Pneumatic sensors
- Proximity switches (magnetic)
- Hall effect sensors

B. Velocity and motion

- Incremental encoder
- Tachogenerator
- Pyroelectric sensors

C. Force

- Strain gauge load cell

D. Fluid pressure

- Diaphragm pressure gauge
- Capsules, bellows, pressure tubes
- Piezoelectric sensors
- Tactile sensor

E. Liquid flow

- Orifice plate
- Turbine meter

F. Liquid level

- Floats
- Differential pressure

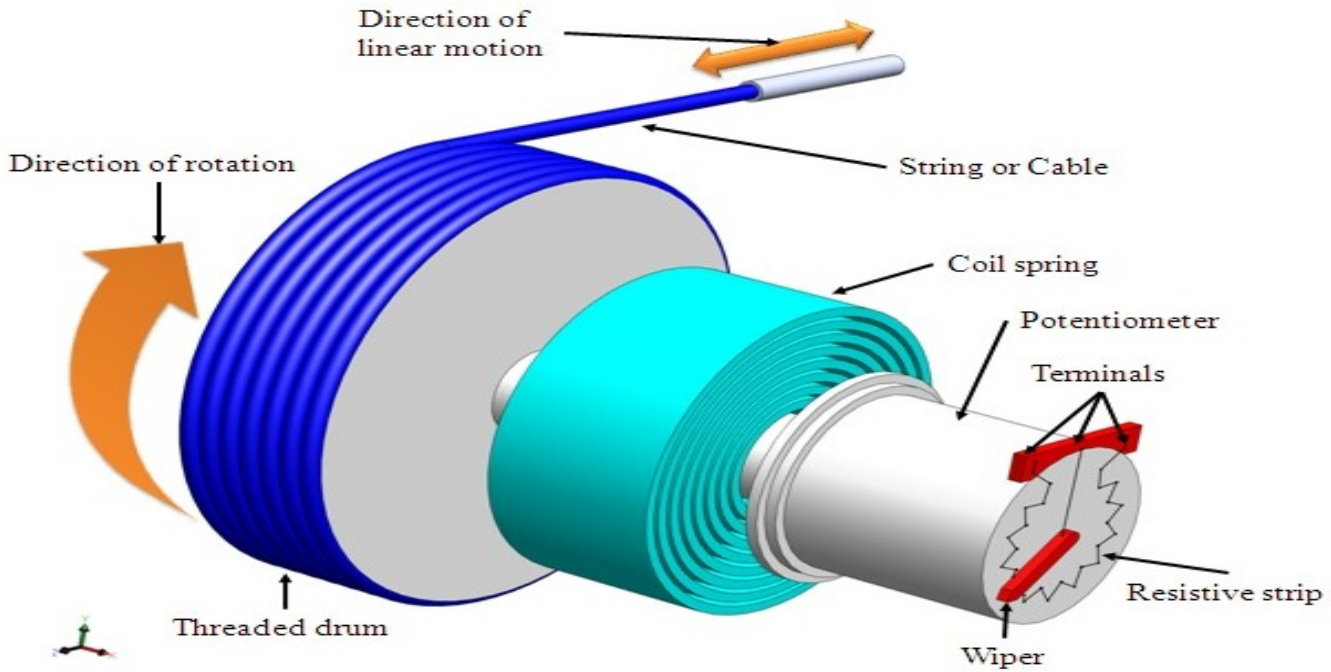
G. Temperature

- Bimetallic strips
- Resistance temperature detectors
- Thermistors
- Thermo-diodes and transistors
- Thermocouples
- Light sensors
- Photo diodes
- Photo resistors
- Photo transistor

DISPLACEMENT SENSOR

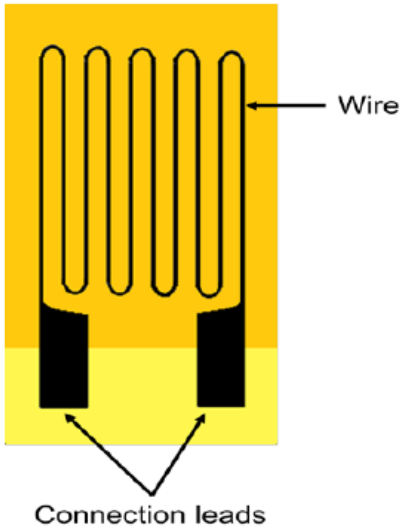
POTENTIOMETER

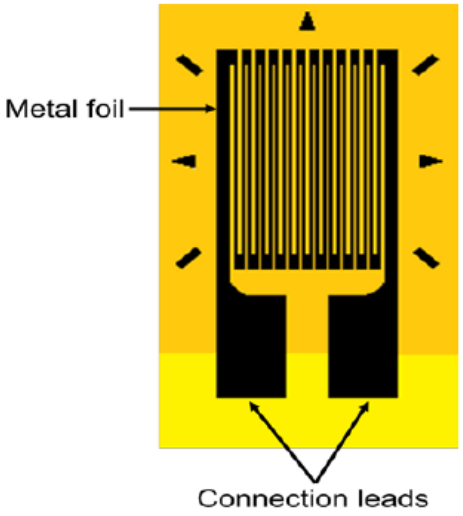
A rotary potentiometer is a variable resistance device that can be used to measure angular position

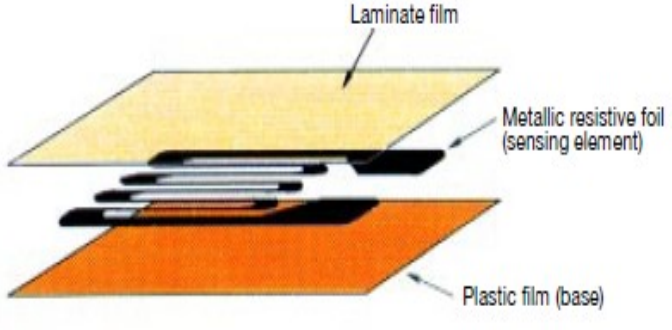


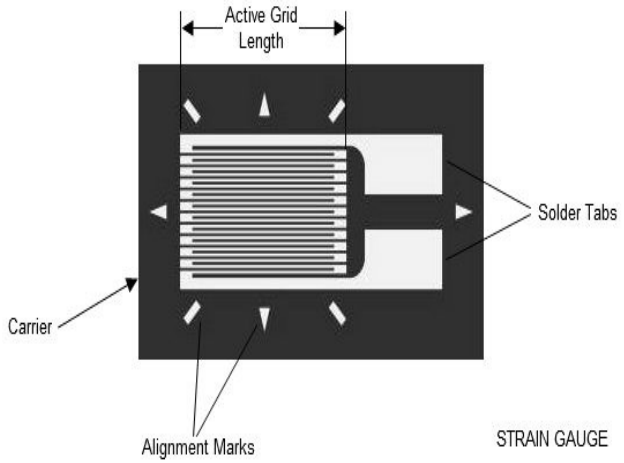
STRAIN GAUAGE

The strain in an element is a ratio of change in length in the direction of applied load to the original length of an element. The strain changes the resistance *R* of the element.



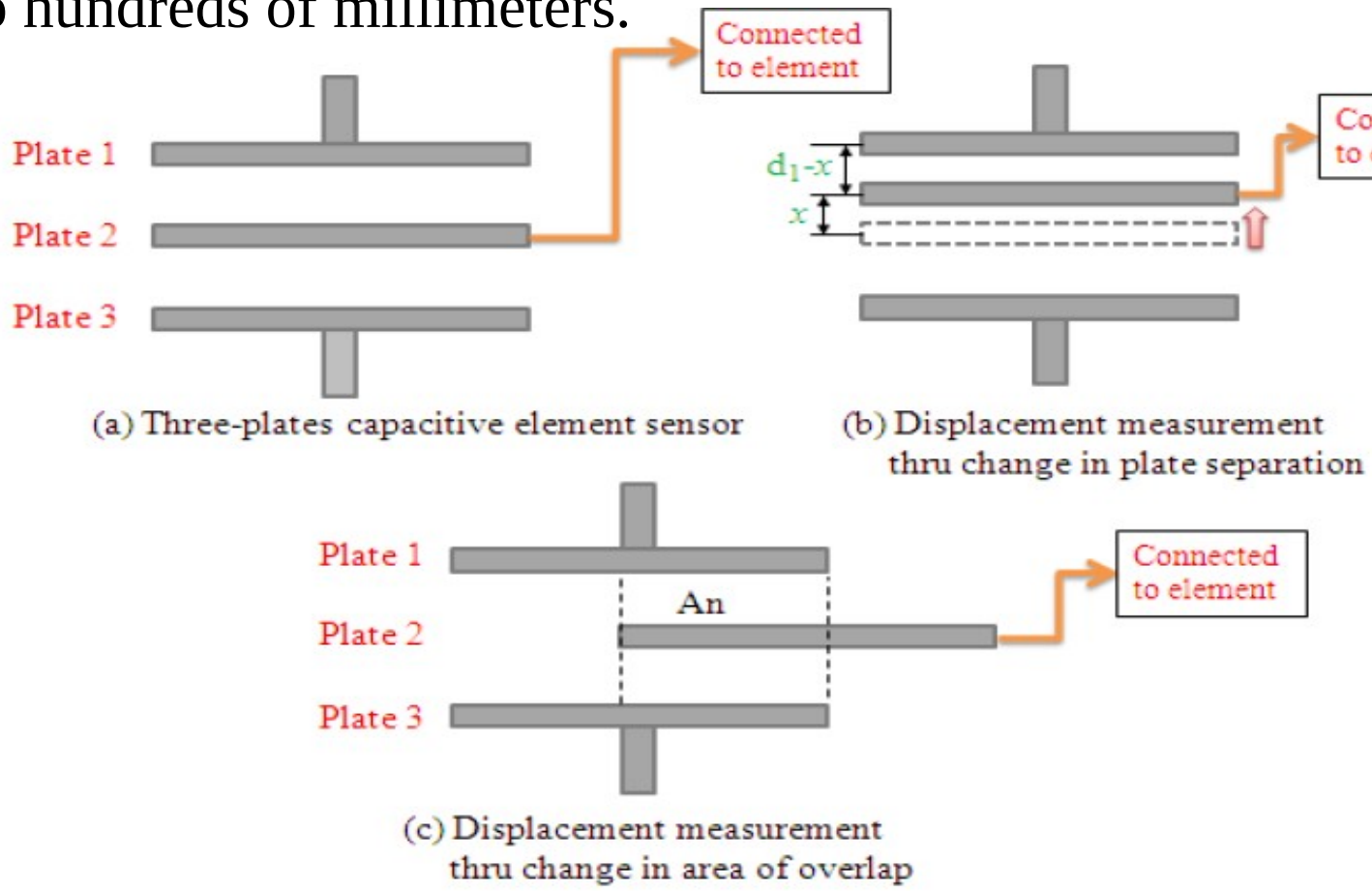




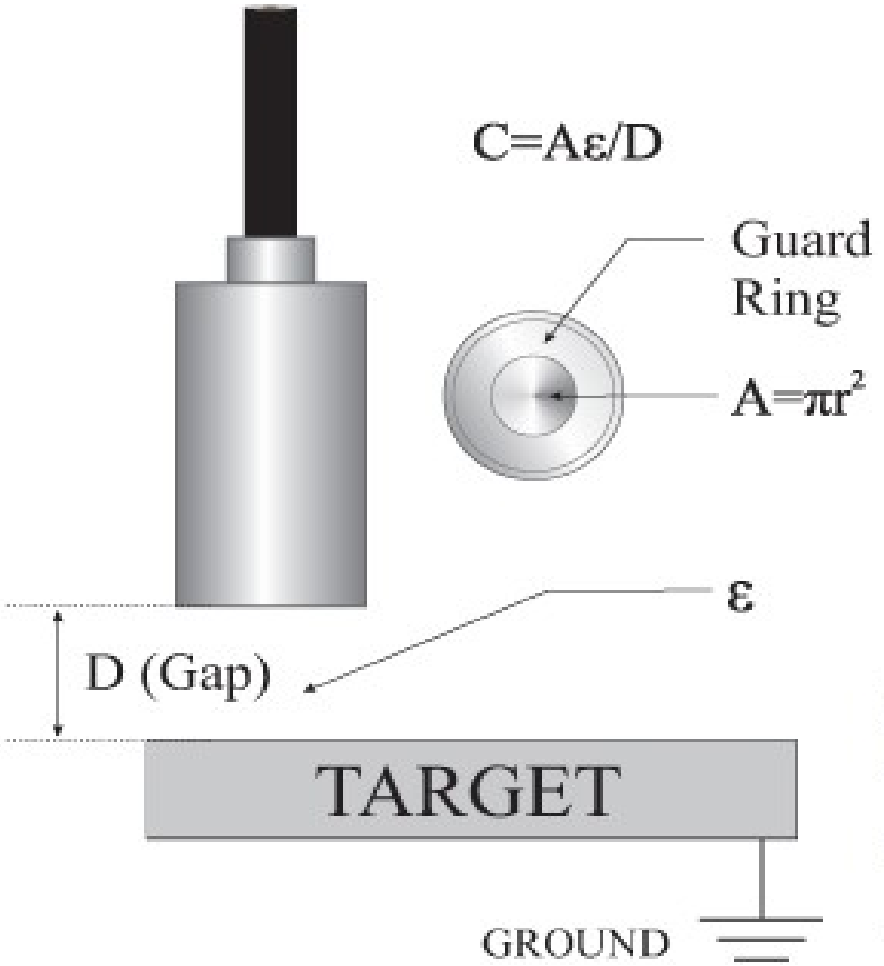


CAPACITIVE ELEMENT BASED SENSOR

Capacitive sensor is of non-contact type sensor and is primarily used to measure the linear displacements from few millimeters to hundreds of millimeters.



Cont..



Where:

C=Capacitance

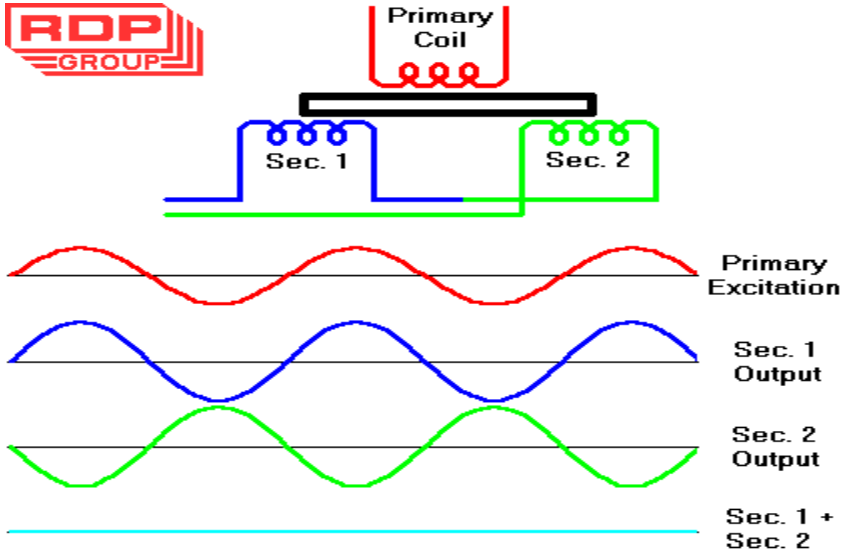
ε= Dielectric constant of the gap medium, typically air

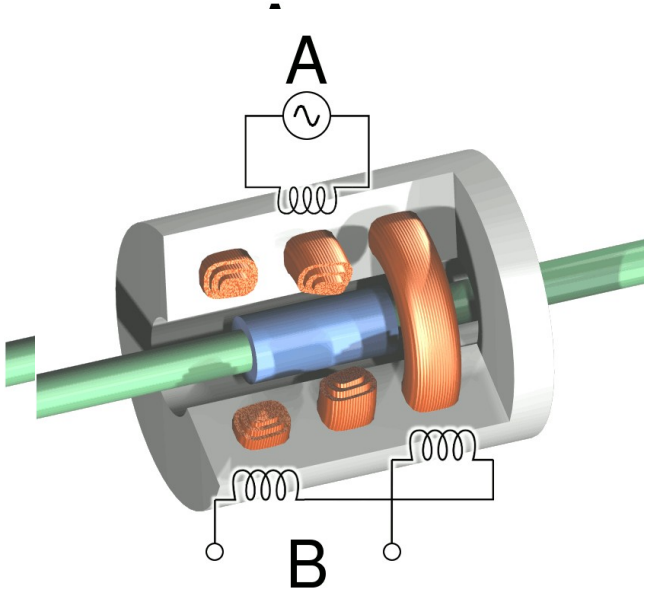
D= Gap distance between the probe and grounded target

A= Probe sensing area

LINEAR VARIABLE DIFFERENTIAL TRANSFORMER

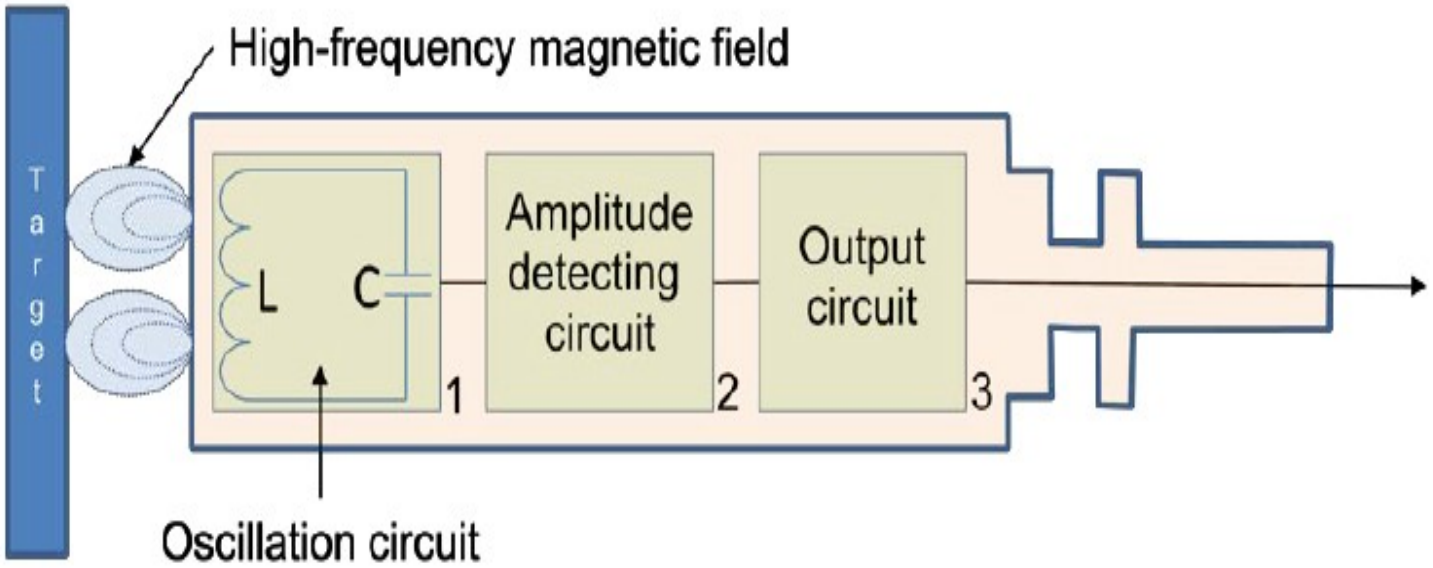
- ‘LVDT’ is a transducer for measuring linear displacement
- It must be excited by an AC signal to induce AC response on secondary.
- The core position can be determined by measuring secondary response.





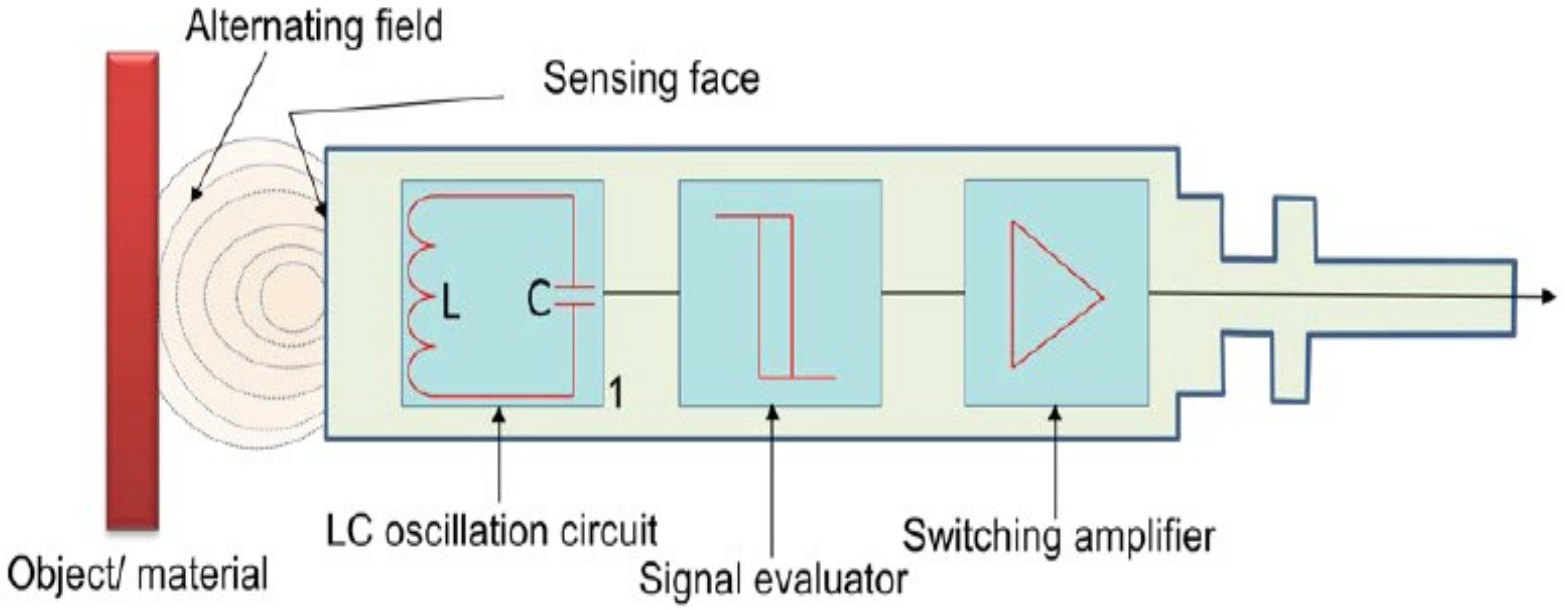
EDDY CURRENT PROXIMITY SENSORS

Eddy current proximity sensors are used to detect non-magnetic but conductive materials. They comprise of a coil, an oscillator, a detector and a triggering circuit.

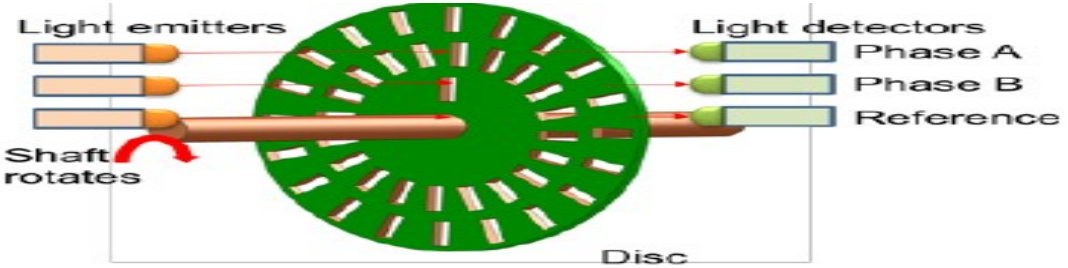


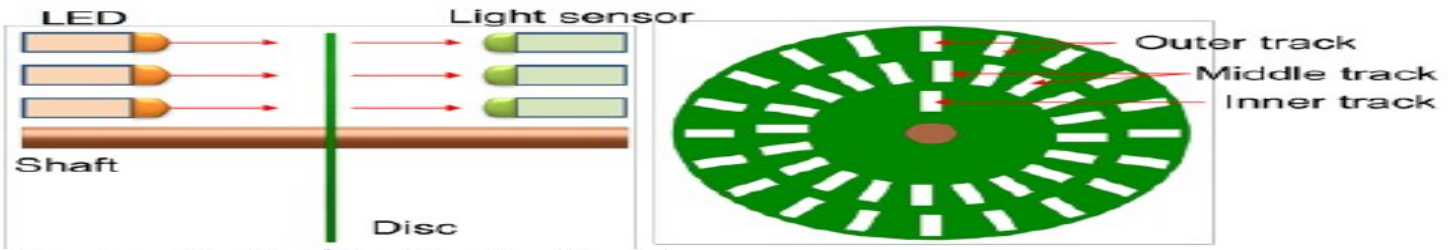
INDUCTIVE PROXIMITY SWITCH

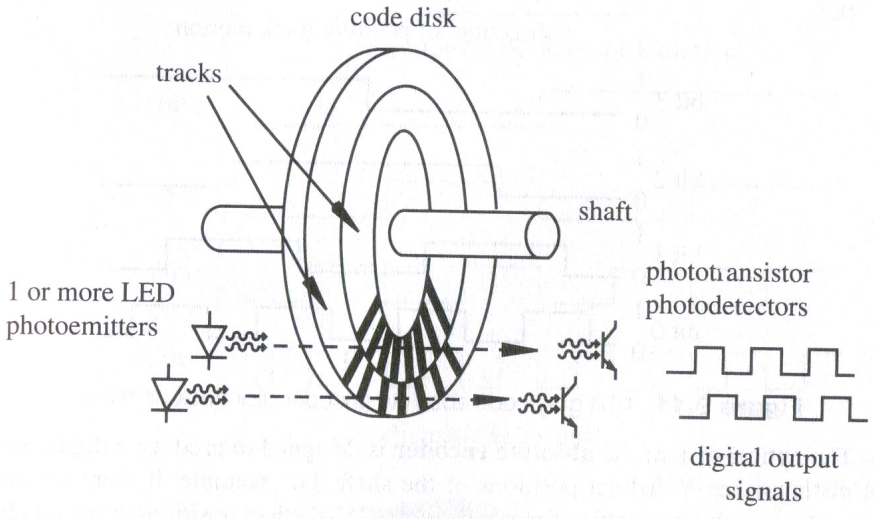
Inductive proximity switches are basically used for detection of metallic objects.



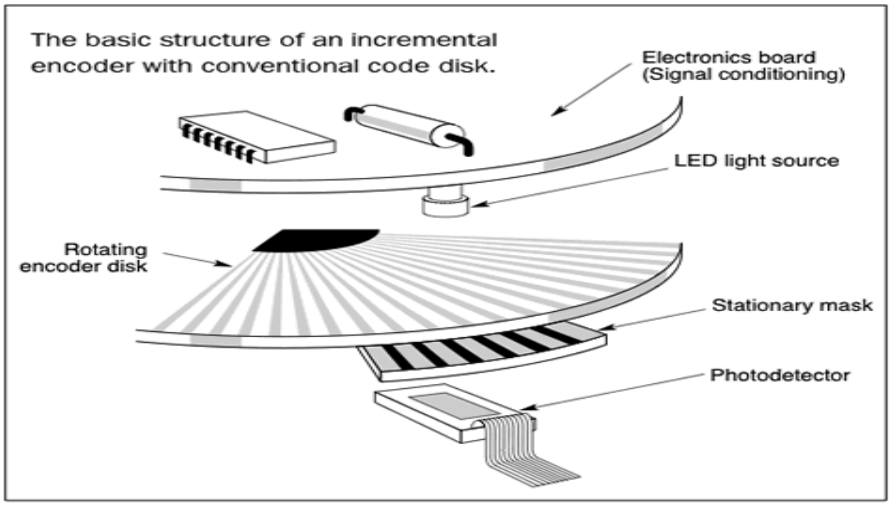
OPTICAL ENCODERS







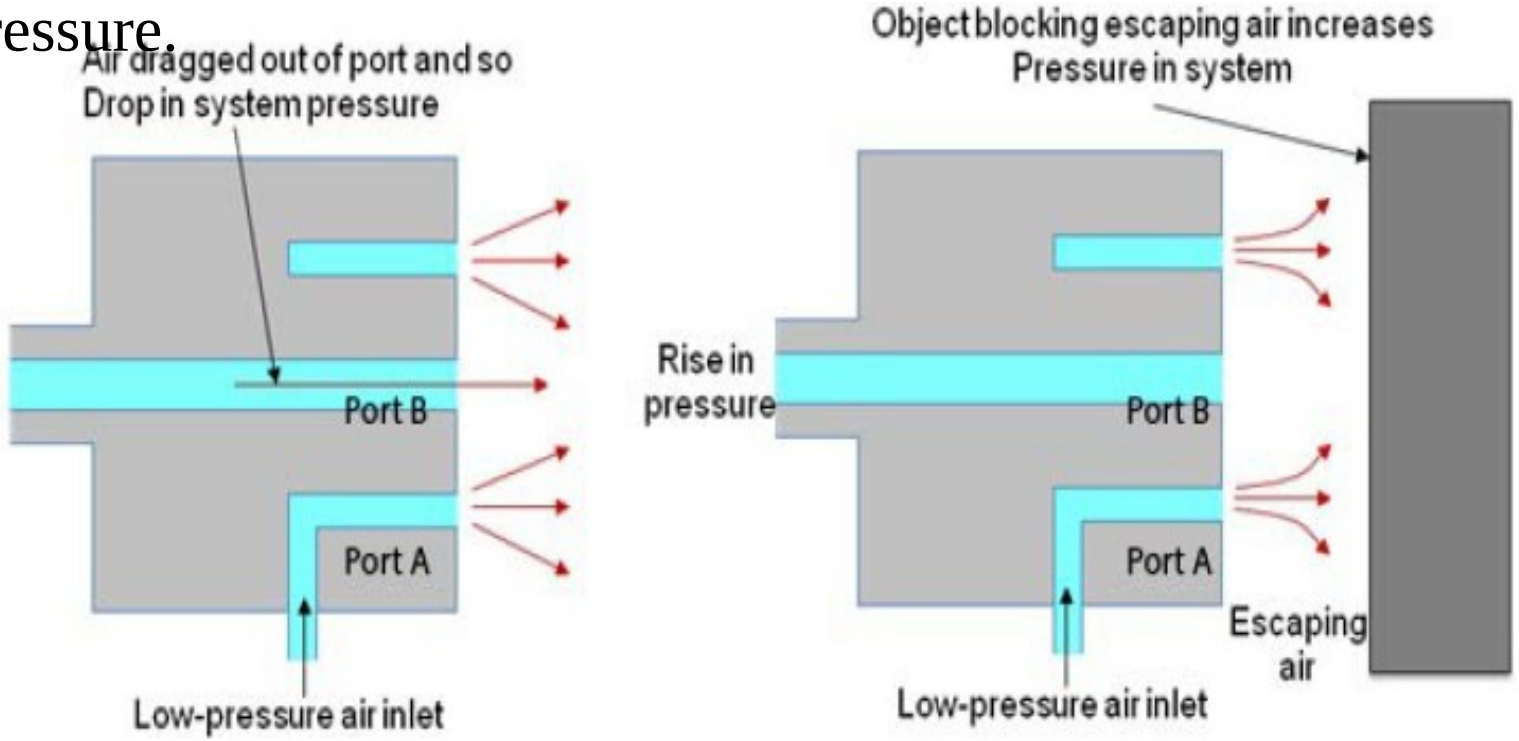
Schematic Diagram



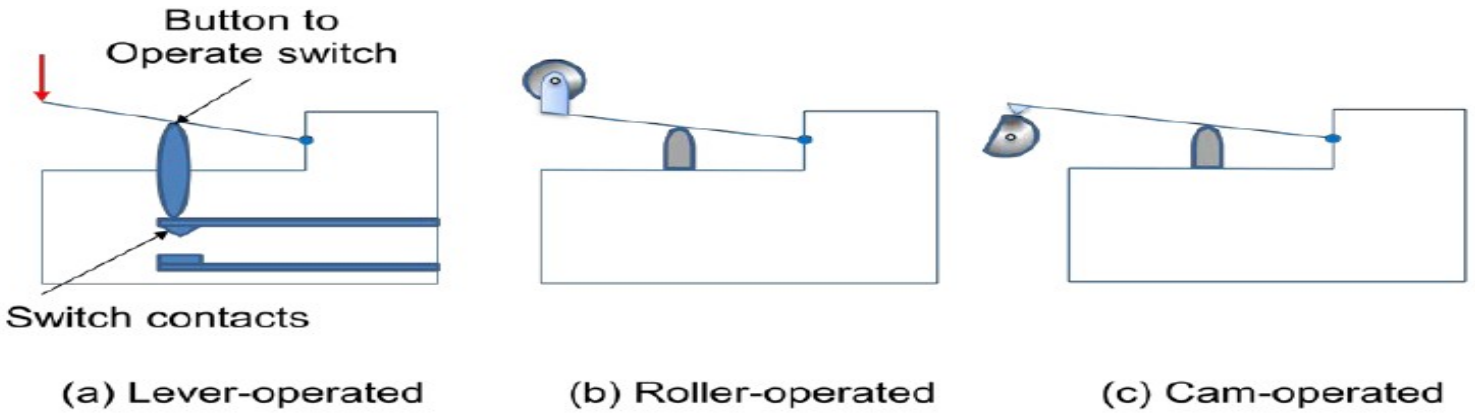
Typical Construction

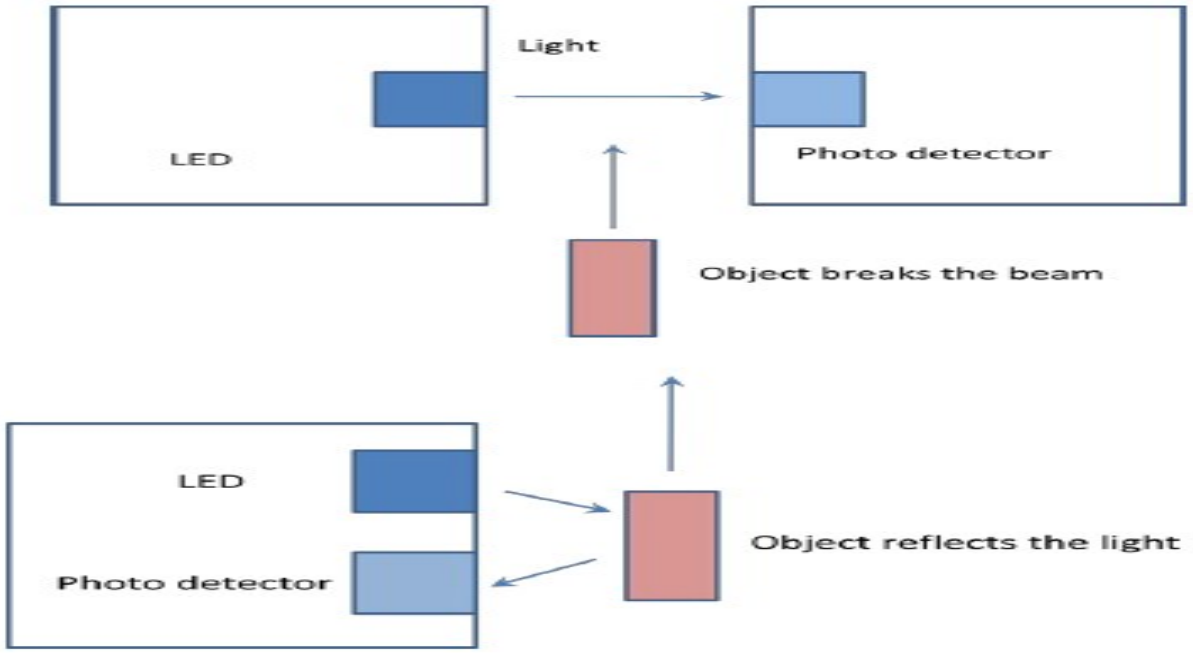
PNEUMATIC SENSORS

Pneumatic sensors are used to measure the displacement as well as to sense the proximity of an object close to it. The displacement and proximity are transformed into change in air pressure.



PROXIMITY SWITCHES



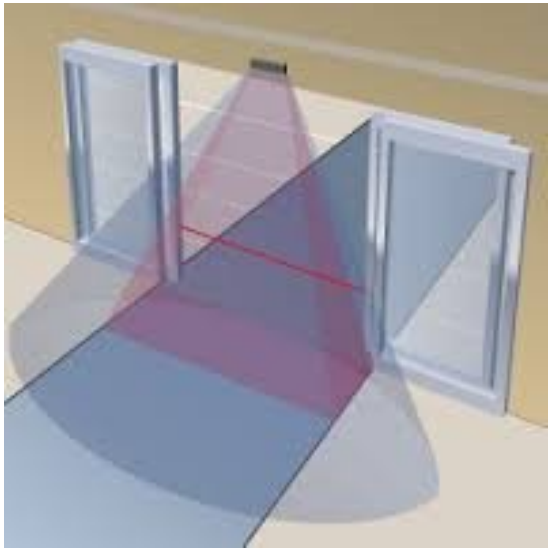


APPLICATION OF PROXIMITY SENSORS



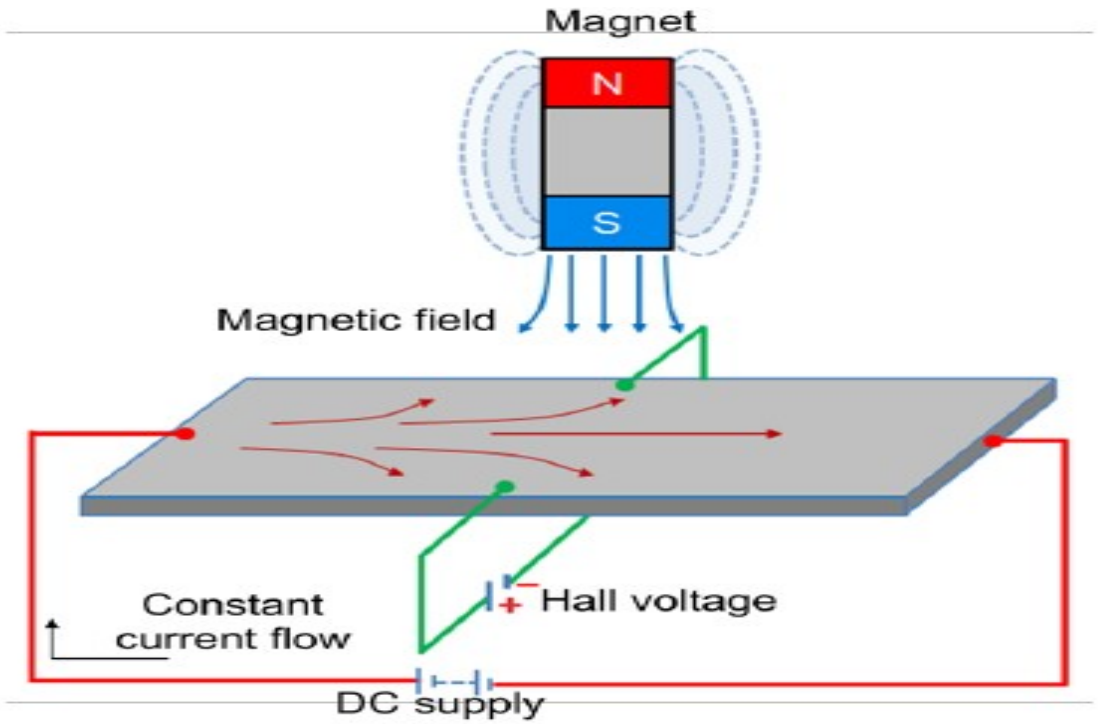






HALL EFFECT SENSOR

. Hall effect sensors work on the principle that when a beam of charge particles passes through a magnetic field, forces act on the particles and the current beam is deflected from its straight line path.

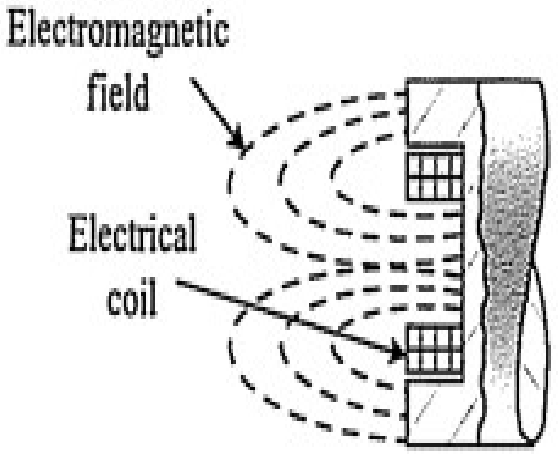


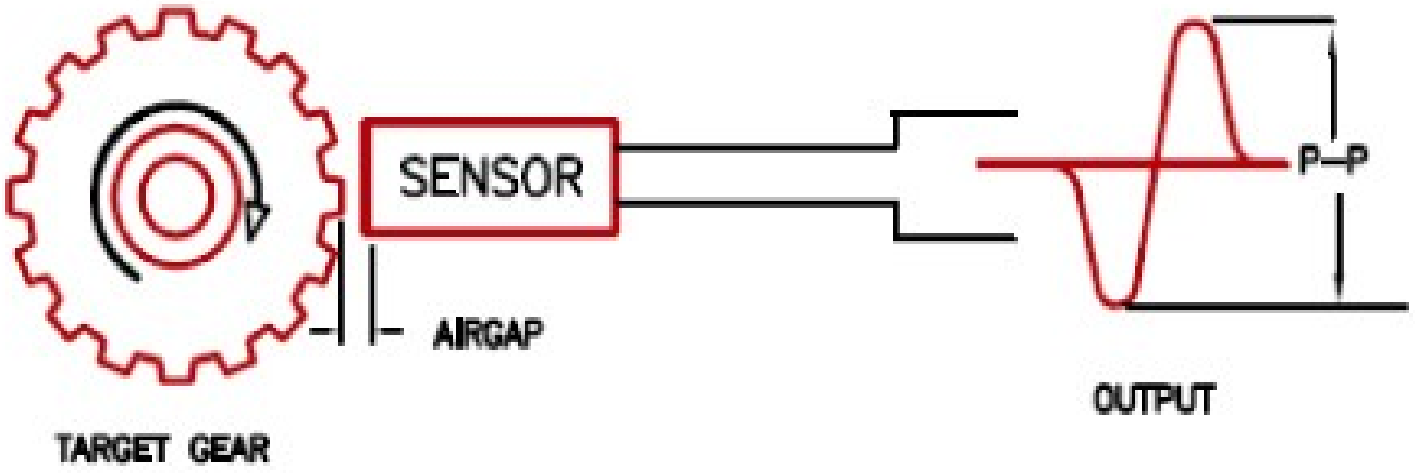
VELOCITY, MOTION, FORCE AND PRESSURE SENSORS

TACHO GENERATOR

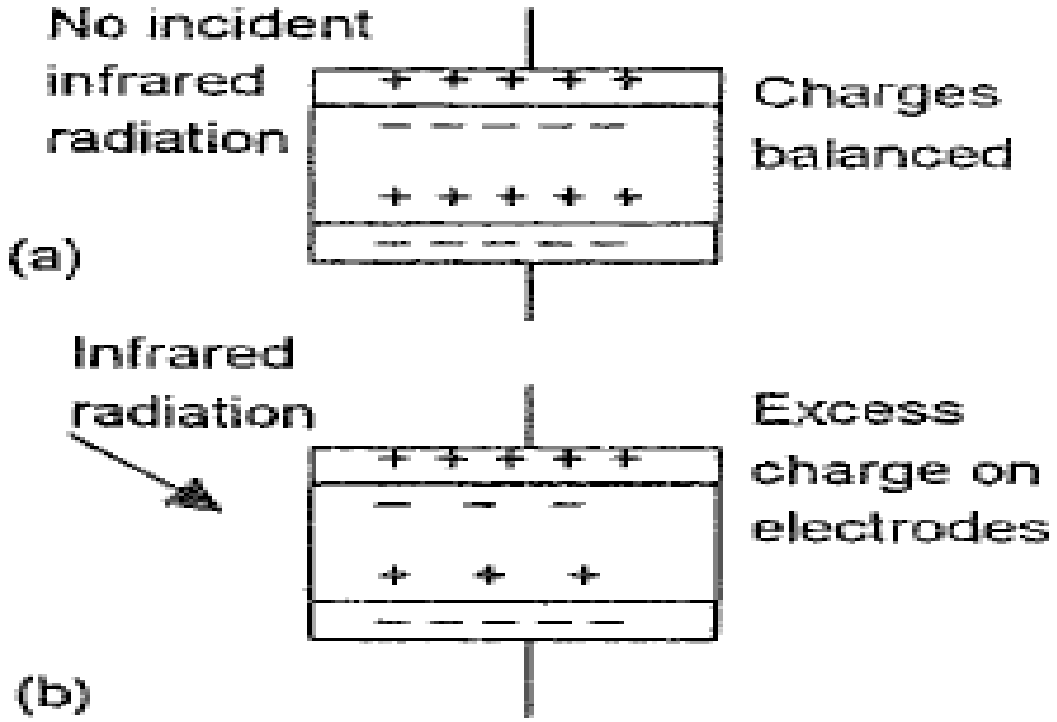
- Tachogenerator works on the principle of variable reluctance.

- It consists of an assembly of a toothed wheel and a magnetic circuit as shown in figure



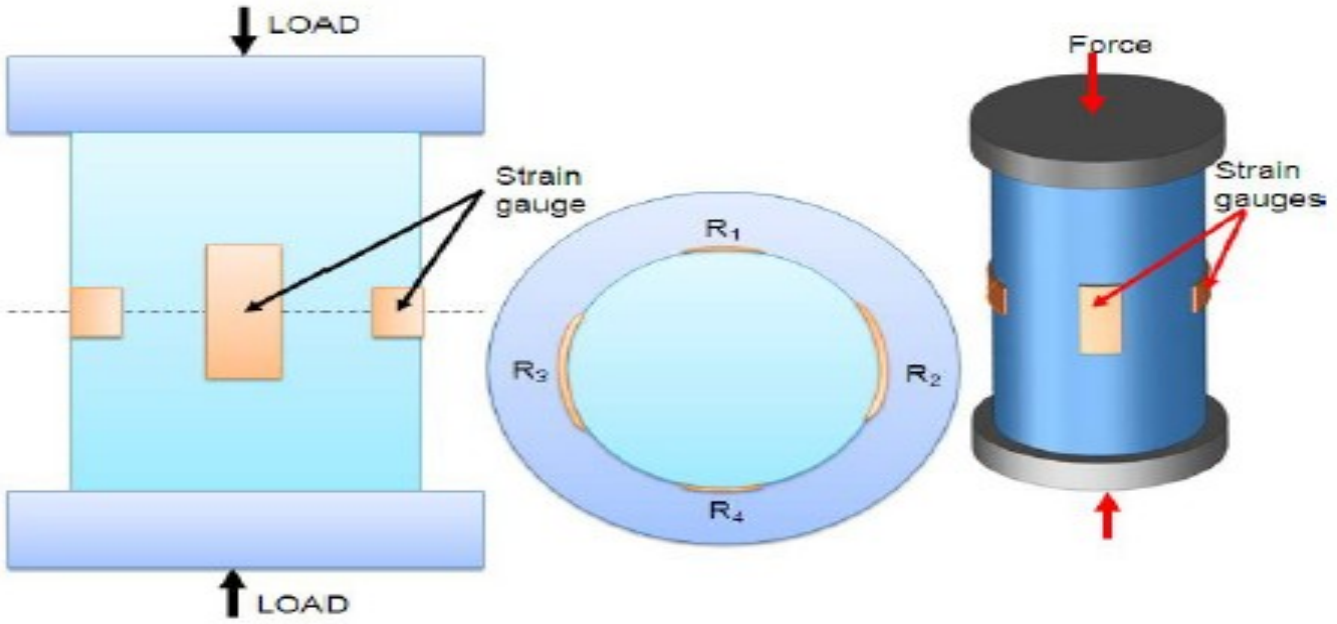


PYROELECTRIC SENSORS

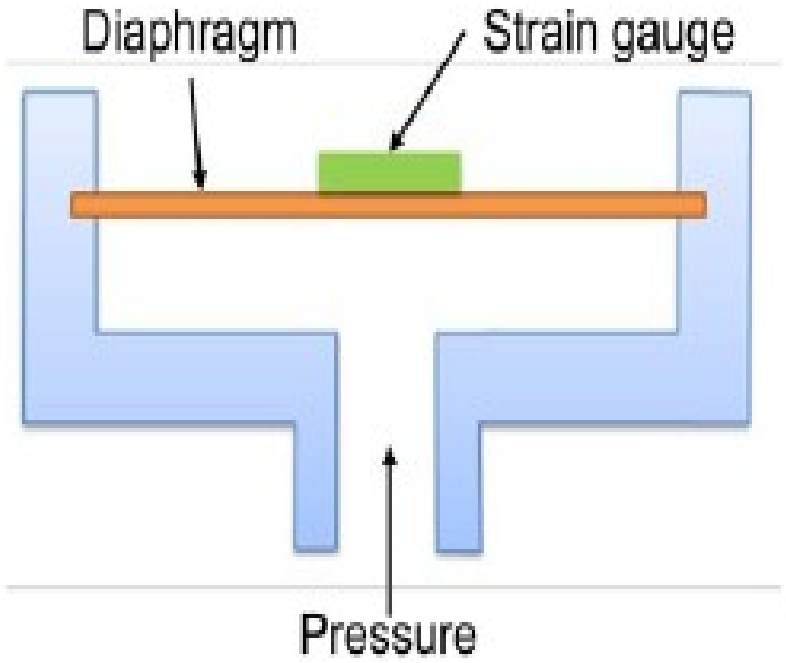


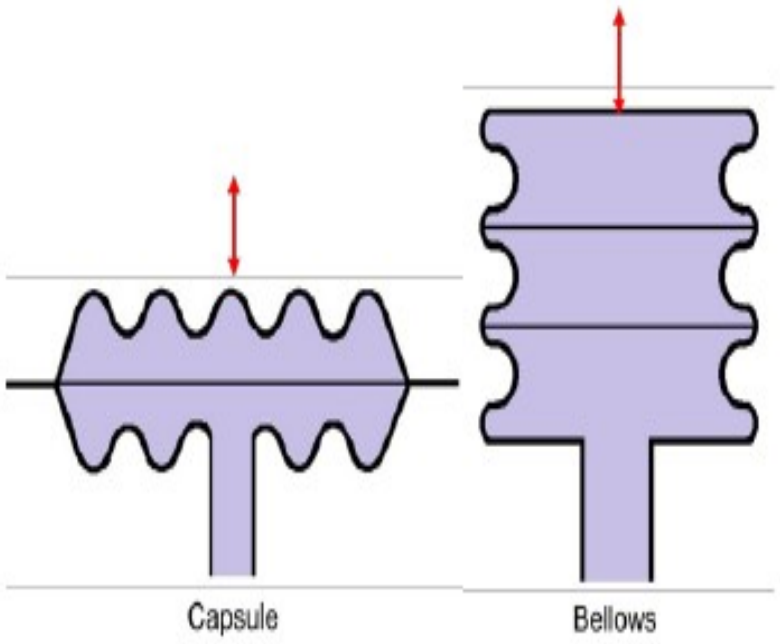
STRAIN GAUGE AS FORCE SENSOR

- Strain gauge based sensors work on the principle of change in electrical resistance.
- When, a mechanical element subjects to a tension or a compression the electric resistance of the material changes. This is used to measure the force acted upon the element.

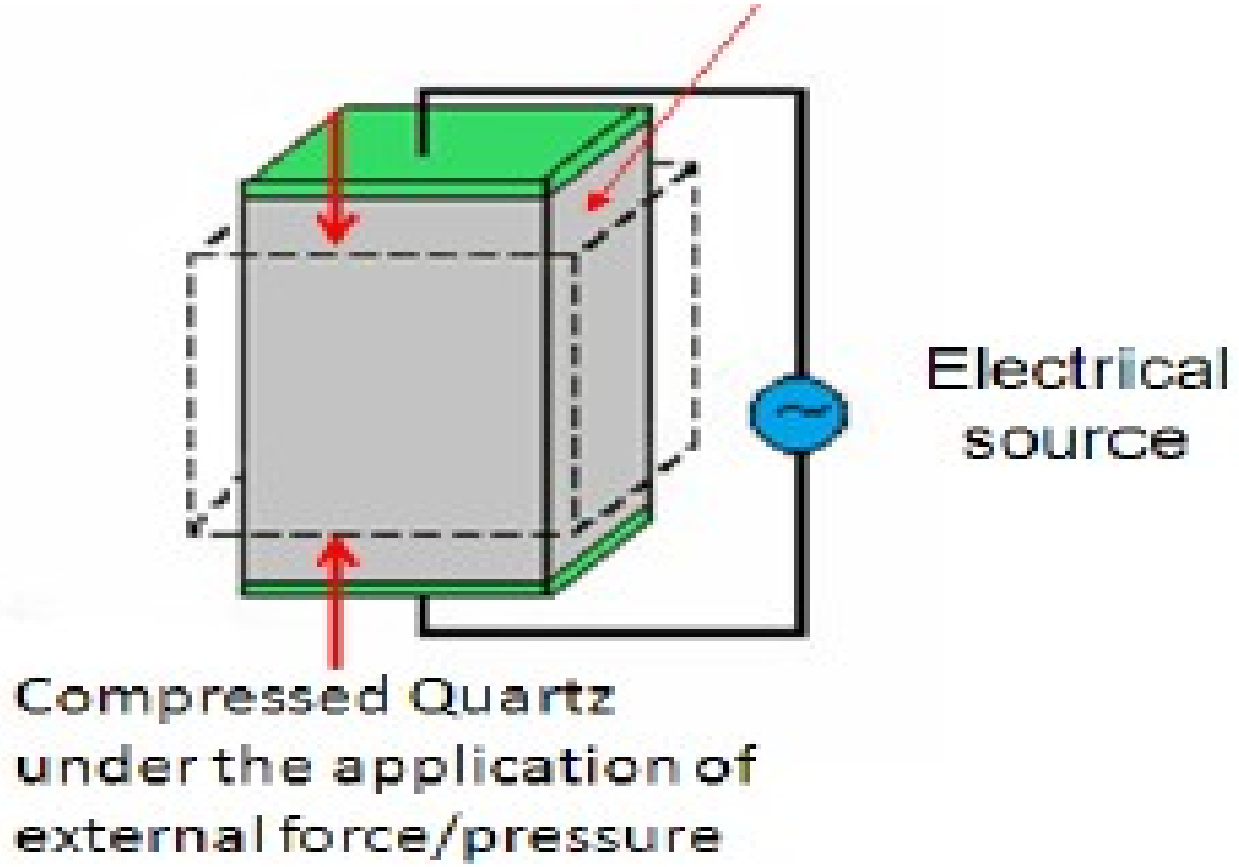


FLUID PRESSURE



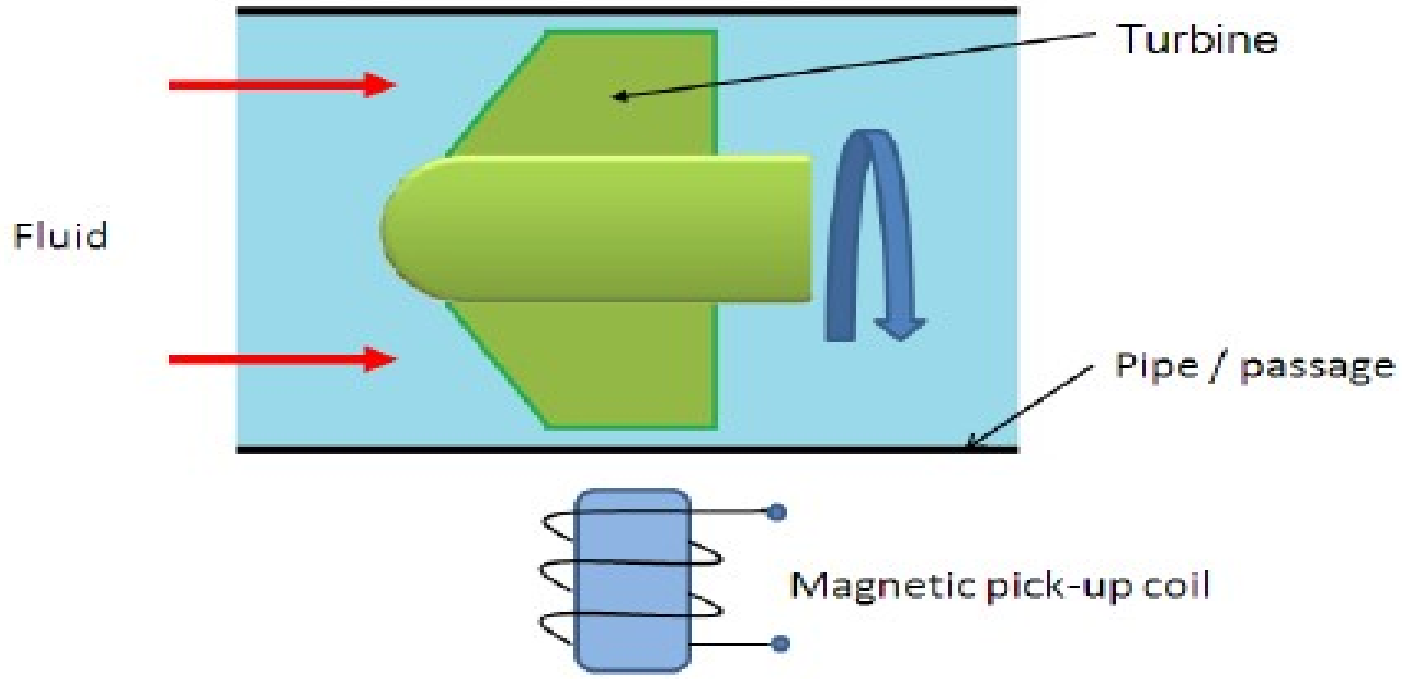


PIEZOELECTRIC SENSOR

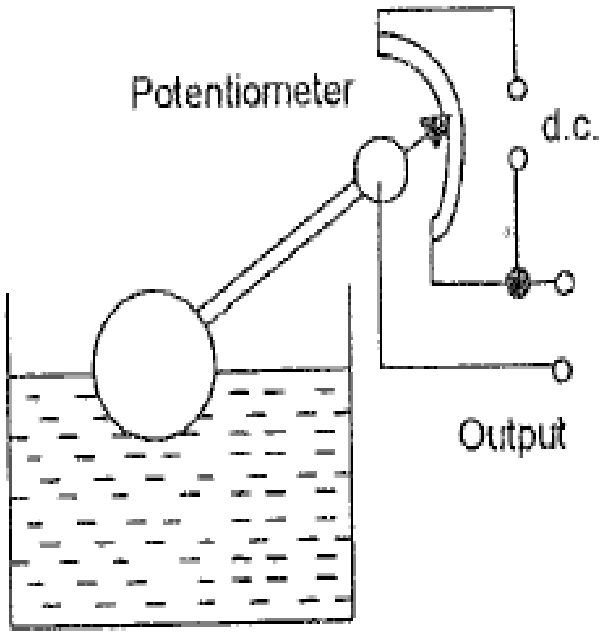


LIQUID FLOW(TURBINE METER)

Turbine flow meter has an accuracy of ±0.3%. It has a multi blade rotor mounted centrally in the pipe along which the flow is to be measured



LIQUID LEVEL



FLOATS

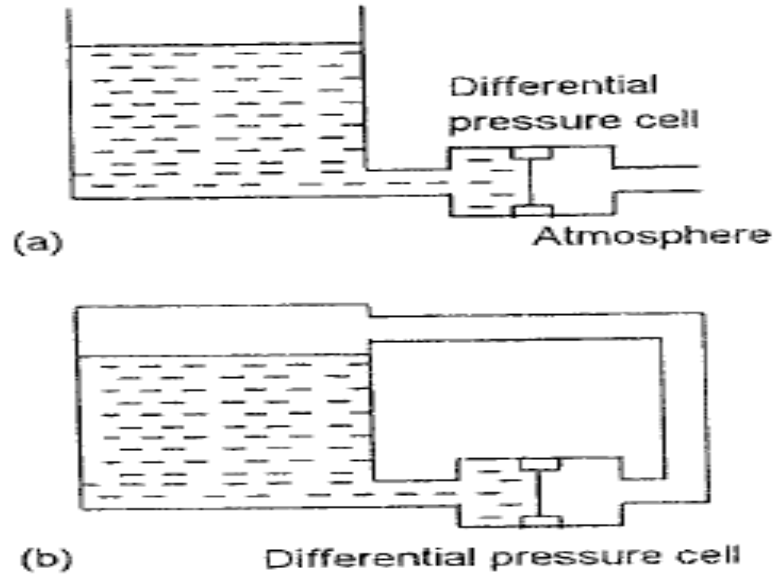


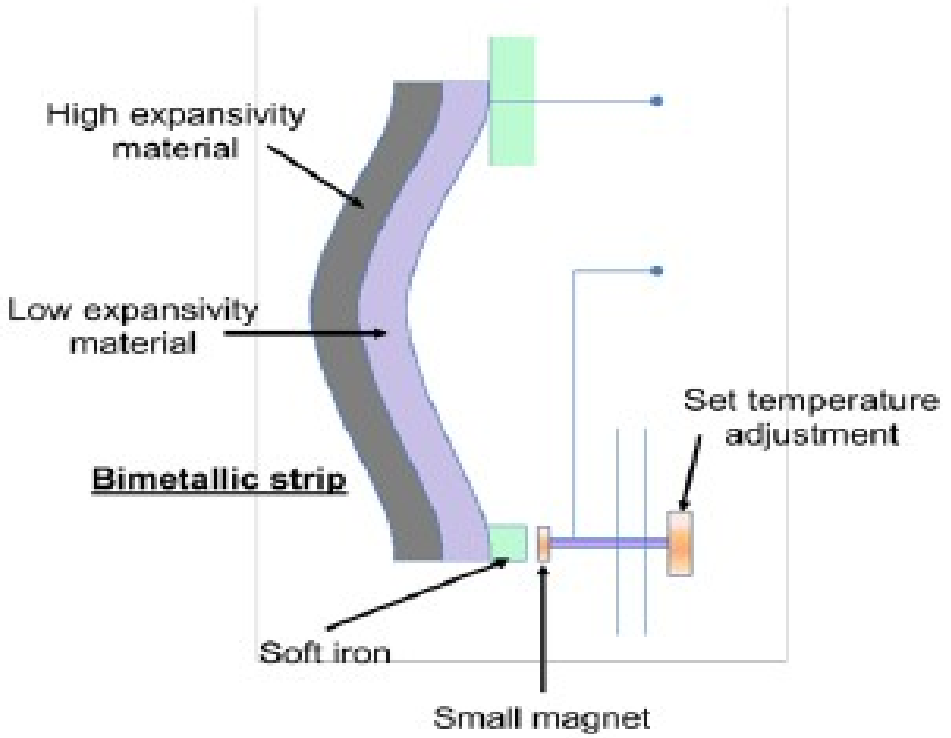
Fig. 2.48 Using a differential pressure sensor

DIFFERENTIAL PRESSURE

TEMPERATURE SENSORS

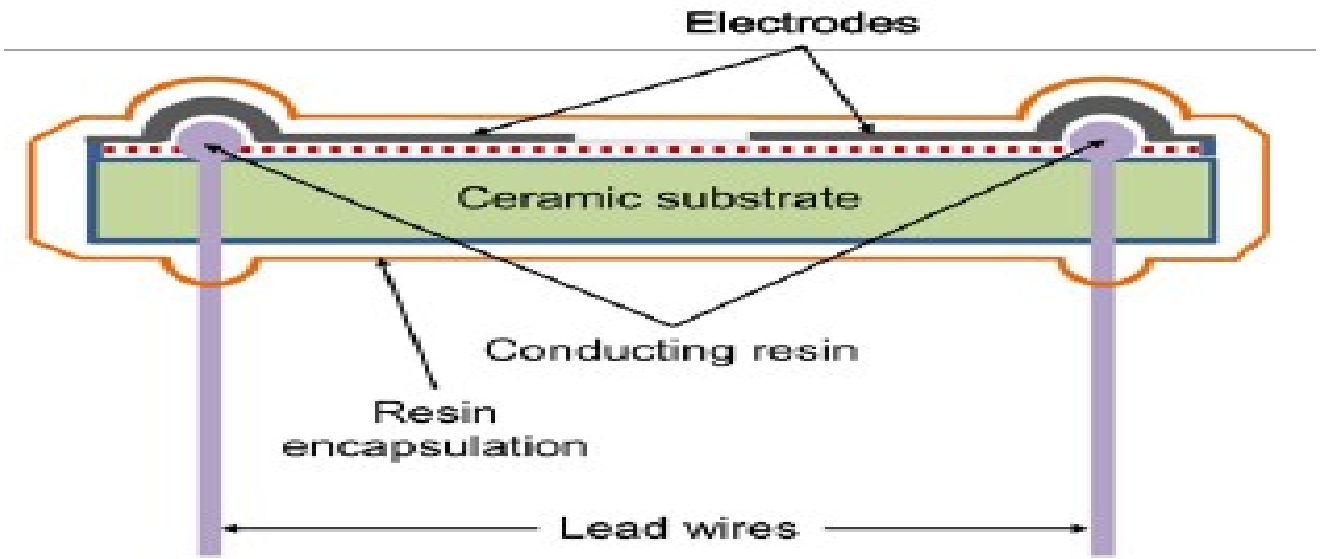
Temperature conveys the state of a mechanical system in terms of expansion or contraction of solids, liquids or gases, change in electrical resistance of conductors, semiconductors and thermoelectric emfs.

BIMETALLIC STRIPS



LIGHT SENSORS

A light sensor is a device that is used to detect light..



SELECTION OF SENSORS

1.Nature of measurement

2. Nature of output required from the sensor.

3.Then possible sensor can be identified