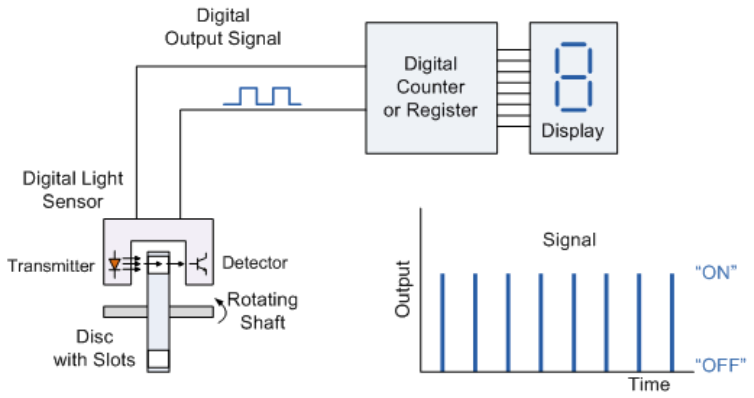
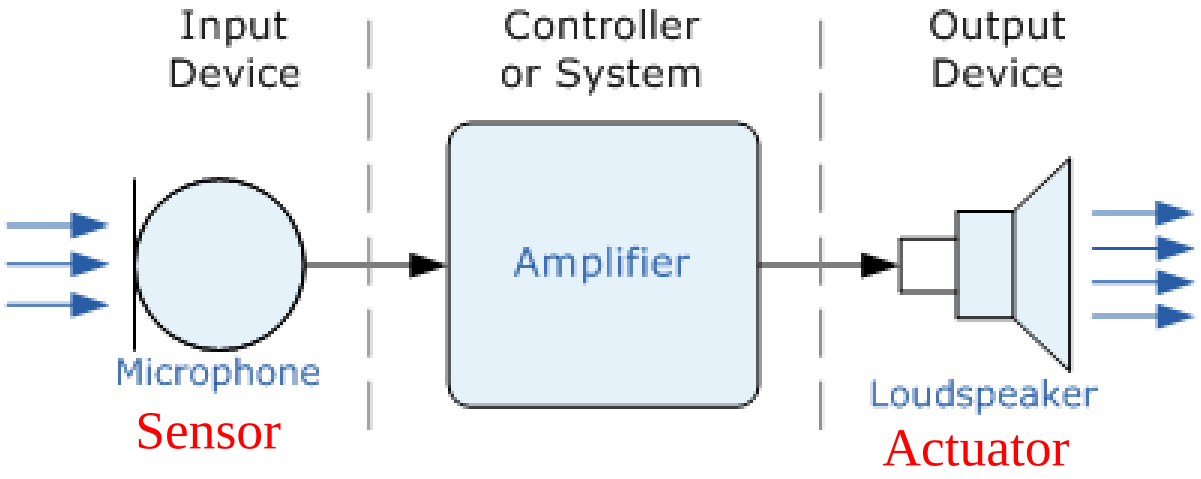


Transducers

EEE355 Industrial Electronics

Terminology

- Transducers convert one form of energy into another
- Sensors/Actuators are input/output transducers
- Sensors can be *passive* (e.g. change in resistance) or *active* (output is a voltage or current level)
- Sensors can be *analog* (e.g. thermocouples) or *digital* (e.g. digital tachometer)

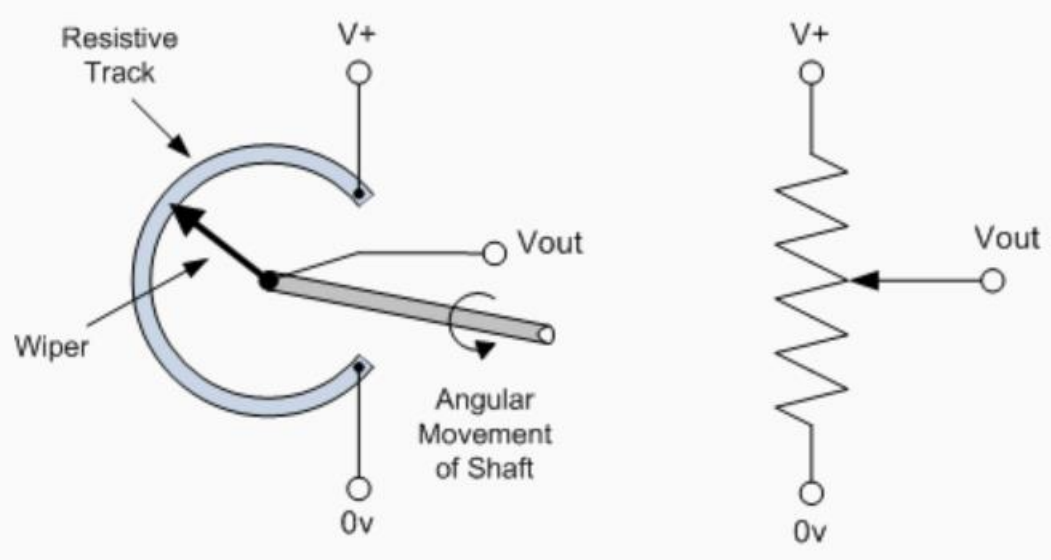


Transducer types

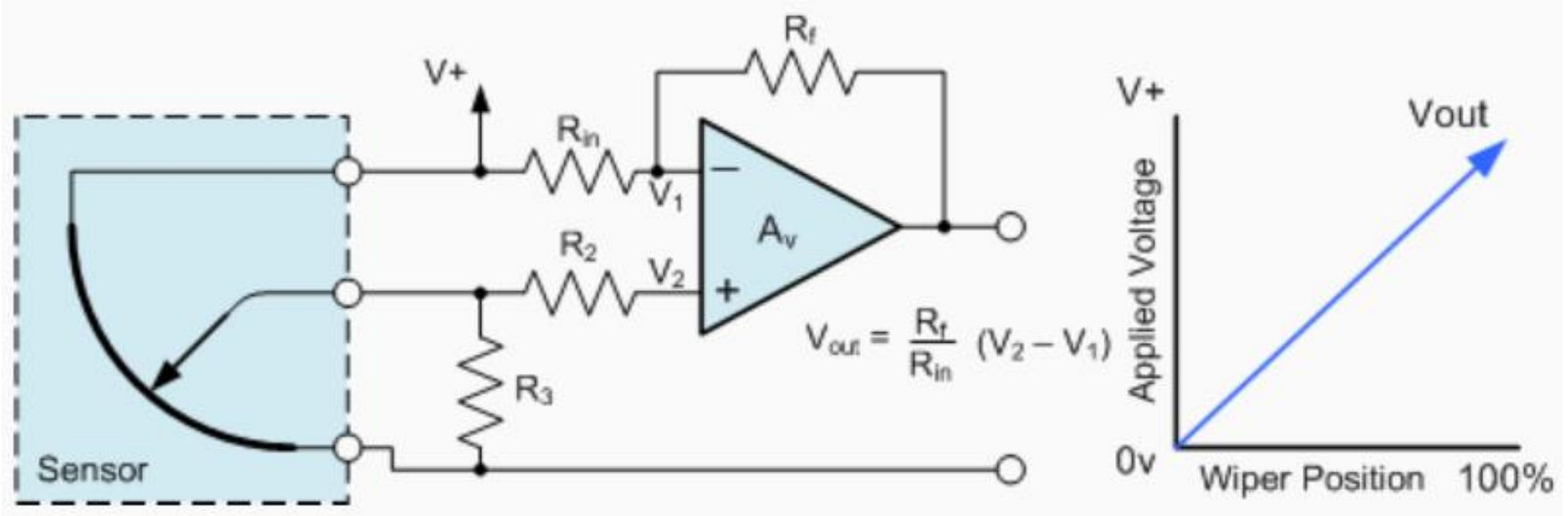
Quantity being Measured	Input Device (Sensor)	Output Device (Actuator)
Light Level	Light Dependant Resistor (LDR), Photodiode, Phototransistor, Solar Cell	Lights & Lamps, LED's & Displays, Fiber Optics
Temperature	Thermocouple, Thermistor, Thermostat, Resistive temperature detectors (RTD)	Heater, Fan, Peltier Elements
Force/Pressure	Strain Gauge, Pressure Switch, Load Cells	Lifts & Jacks, Electromagnetic, Vibration
Position	Potentiometer, Encoders, Reflective/Slotted Opto-switch, LVDT	Motor, Solenoid, Panel Meters
Speed	Tacho-generator, Reflective/Slotted Opto-coupler, Doppler Effect Sensors	AC and DC Motors, Stepper Motor, Brake
Sound	Carbon Microphone, Piezo-electric Crystal	Bell, Buzzer, Loudspeaker

Positional Sensors: potentiometer

Can be Linear or Rotational

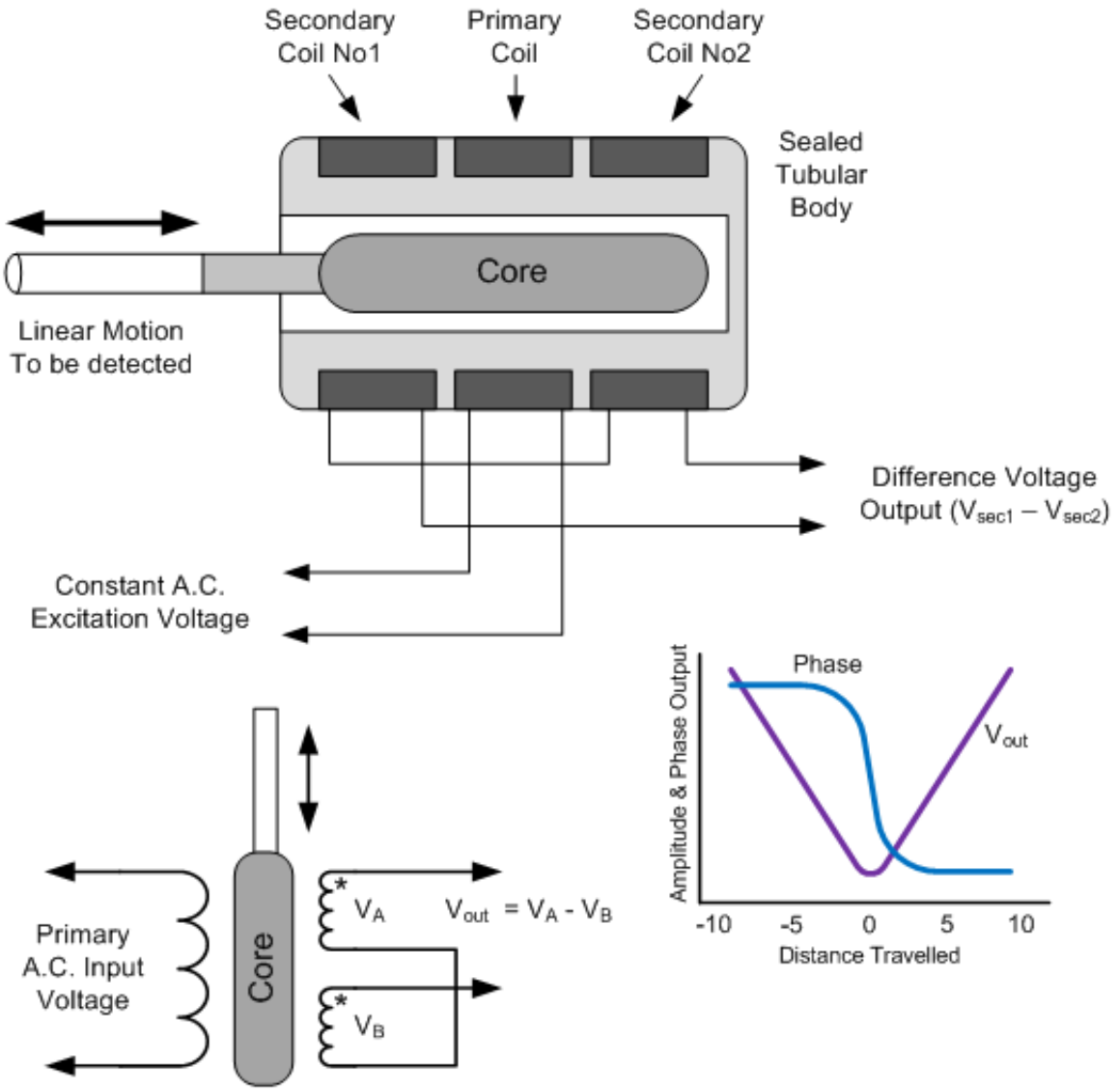


Processing circuit



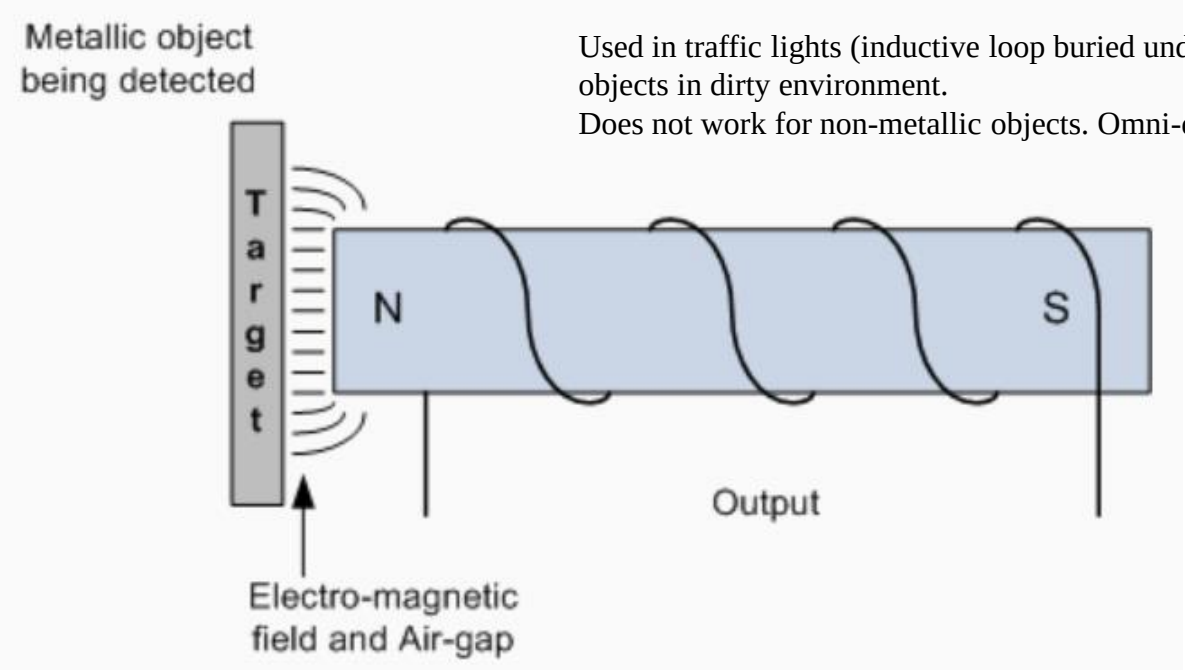
Positional Sensors: LVDT

Linear Variable Differential Transformer



Positional Sensors: Inductive Proximity Switch

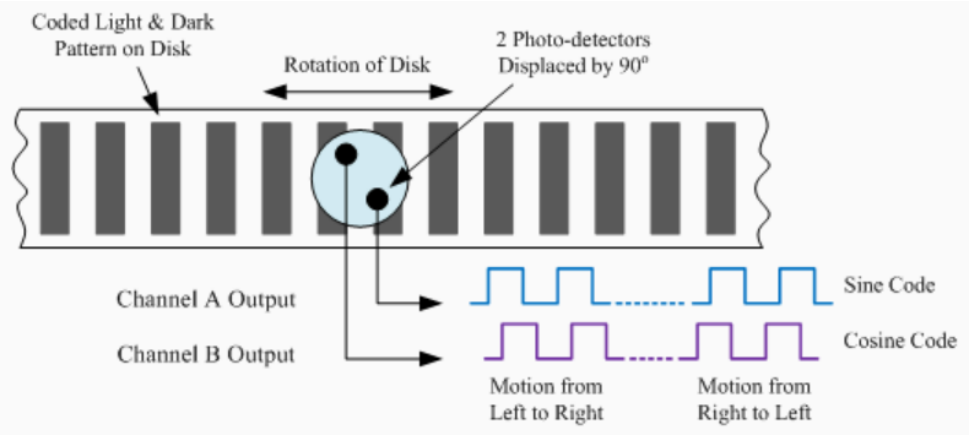
- Detects the presence of metallic objects (non-contact) via changing inductance
- Sensor has 4 main parts: field producing Oscillator via a Coil; Detection Circuit which detects change in the field; and Output Circuit generating a signal (NO or NC)

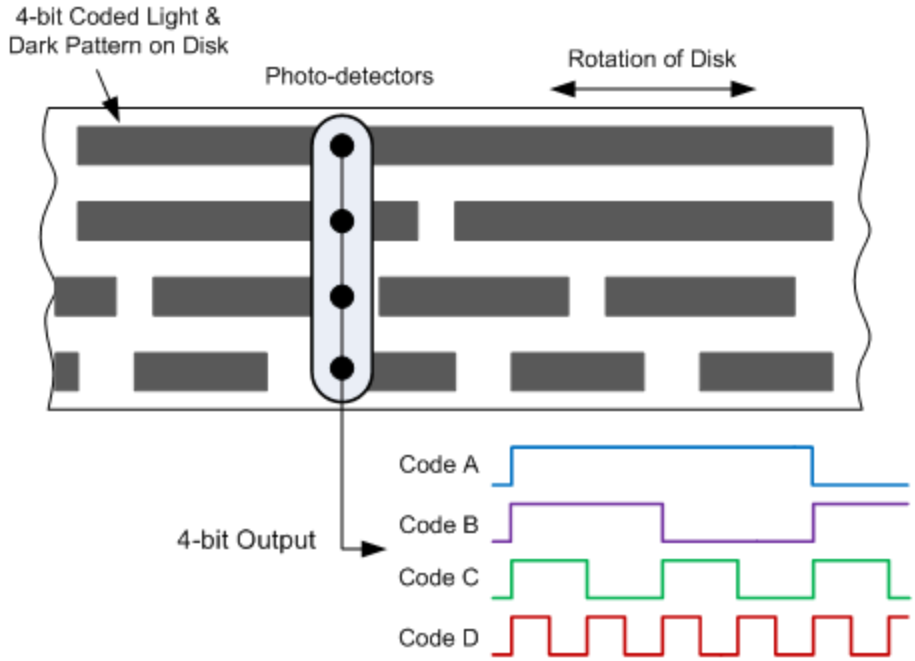


Used in traffic lights (inductive loop buried under the road). Sense objects in dirty environment.
Does not work for non-metallic objects. Omni-directional.

Positional Sensors: Rotary Encoders

- Incremental and absolute types
- Incremental encoder needs a counter, loses absolute position between power glitches, must be re-homed
- Absolute encoders common in CD/DVD drives

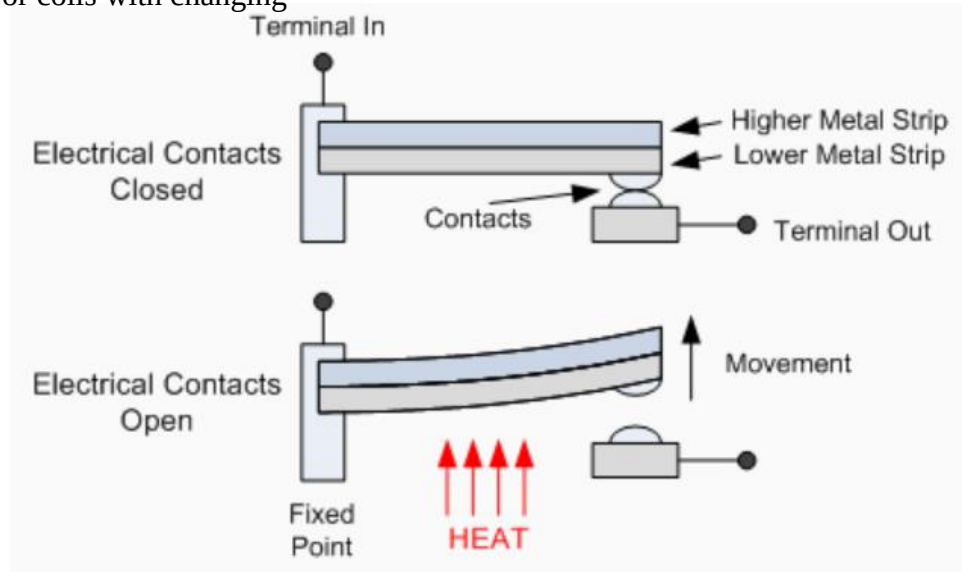




Temperature Sensors

- Bimetallic switch (electro-mechanical) – used in thermostats. Can be “creep” or “snap” action.

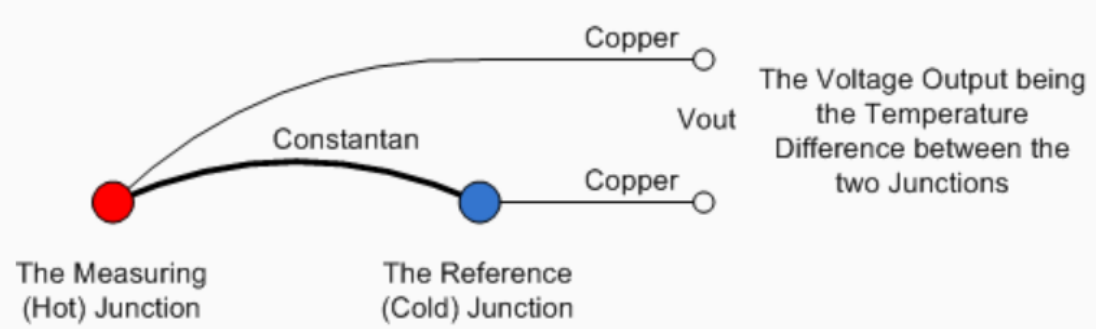
Creep-action: coil or spiral that unwinds or coils with changing temperature



- Thermistors (thermally sensitive resistors); Platinum Resistance Thermometer (PRT), very high accuracy.

Thermocouples

- Two dissimilar metals induce voltage difference (few mV per 10K) – electro-thermal or Seebeck effect



- Use op-amp to process/amplify the voltage
- Absolute accuracy of 1K is difficult

Thermocouple Sensor Colour Codes

Extension and Compensating Leads

Code Type	Conductors (+/-)	Sensitivity	British BS 1843:1952
E	Nickel Chromium / Constantan	-200 to 900°C	
J	Iron / Constantan	0 to 750°C	
K	Nickel Chromium / Nickel Aluminium	-200 to 1250°C	
N	Nicrosil / Nisil	0 to 1250°C	
T	Copper / Constantan	-200 to 350°C	
U	Copper / Copper Nickel Compensating for "S" and "R"	0 to 1450°C	

PRESSURE SENSOR

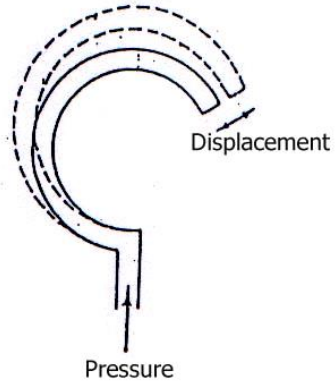
Can be divided into three types:

1. **Deflection type**
2. **Strain gauge type**
3. **Piezoelectric type**

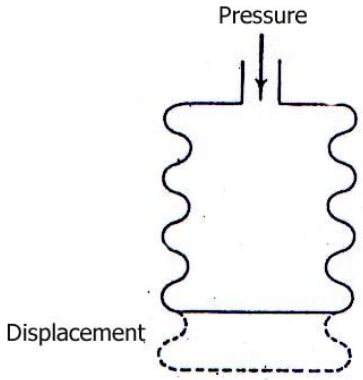
Typical Pressure Detector System

1. DEFLECTION TYPE PRESSURE SENSOR

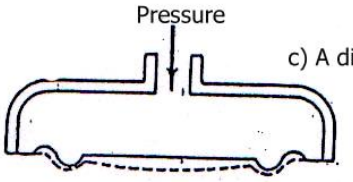
- This sensor uses an elastic material to convert pressure to displacement e.g. stainless steel, brass.
- The displacement will be proportionate to the value of pressure exerted.
- Suitable to be used in an automatic control system.
- The main element used is in the shape of Bourdon tube, bellow or diaphragm.
- The secondary element is the element that will convert the displacement to electrical signals where the displacement can be detected through resistivity change, inductance or capacitance.



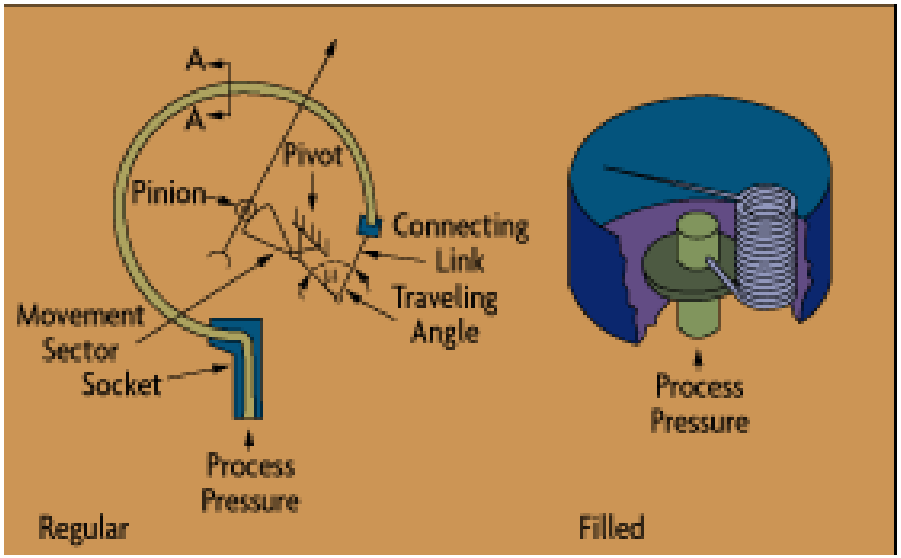
a) A Circular Bourdon pressure element



b) A bellows pressure element

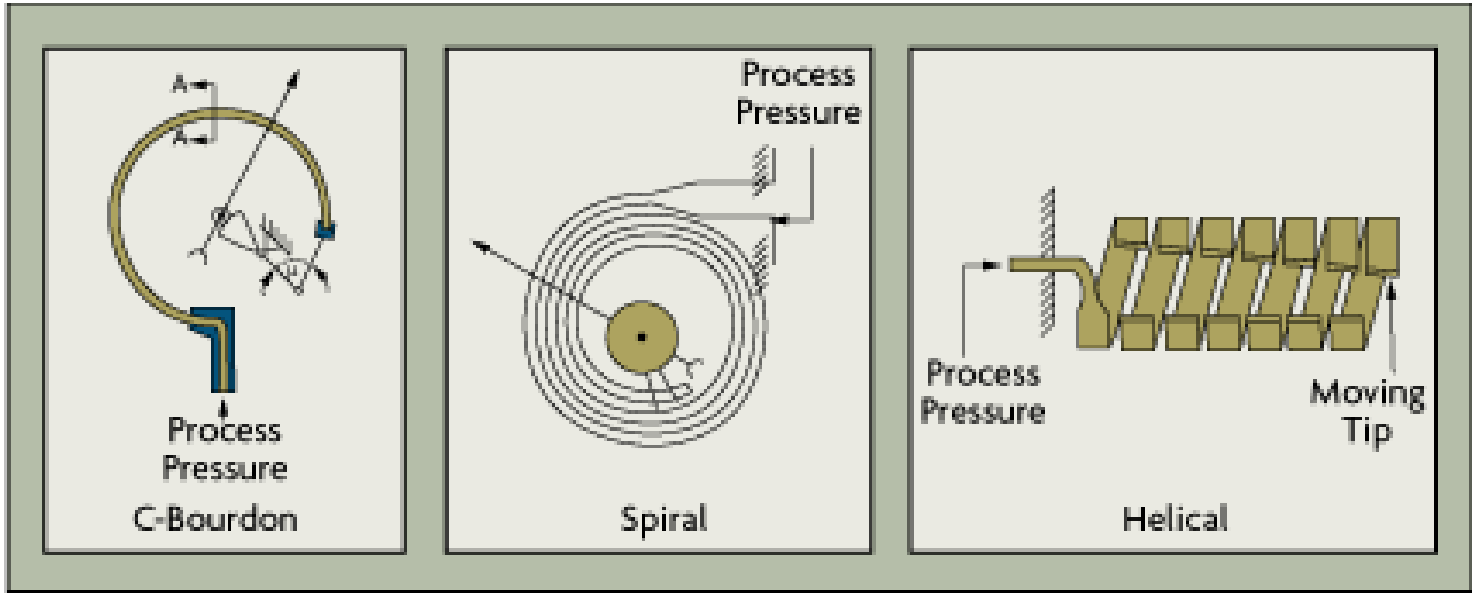


c) A diaphragm pressure element



The Main Typical Element Used In A Deflection Type Pressure Sensor

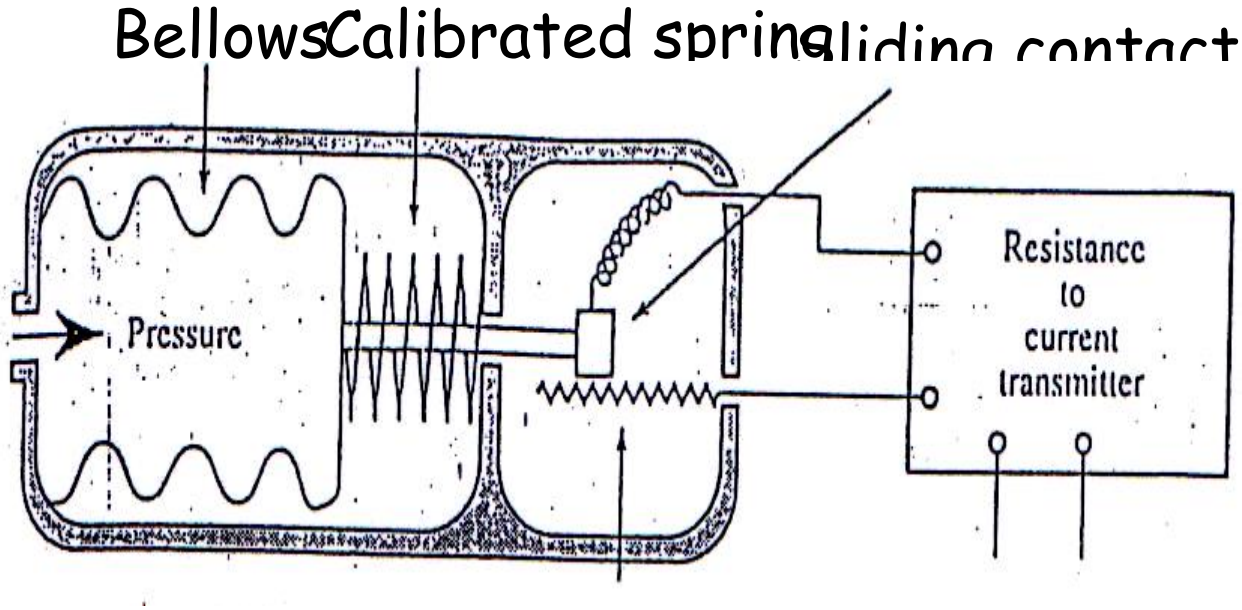
Basic Form of Mechanical Pressure Sensors



Example :

i. **Bellow-resistance pressure sensor**

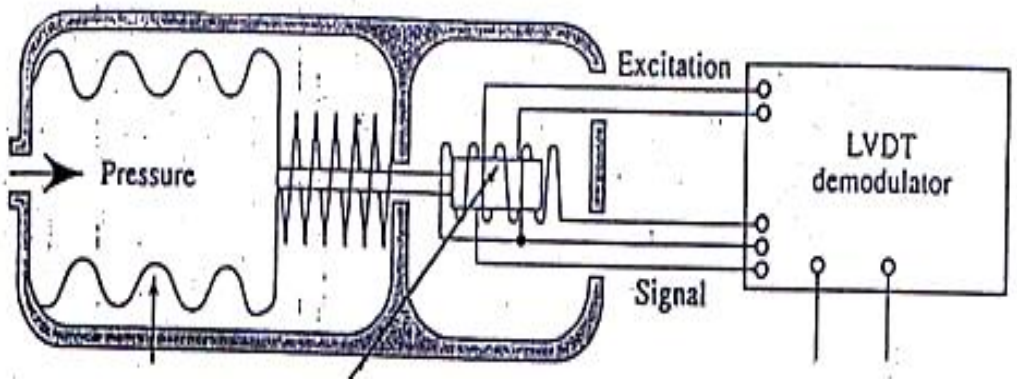
- **The pressure is proportionate to the resistivity.**
- **The resistance change is detected by displacement of sliding contact in the resistance element.**



Example :

ii. **Bellow-inductance pressure sensor**

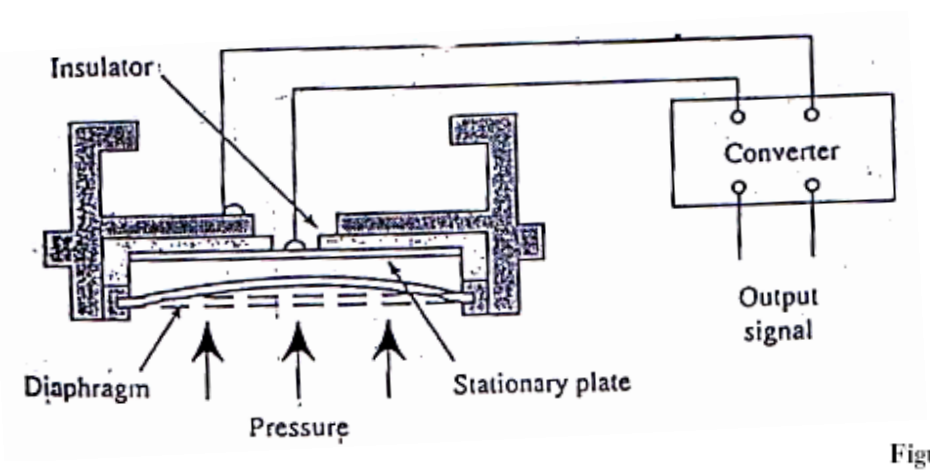
- **The pressure is proportionate to the inductance change which is detected from the displacement of the core in the wire coil.**
- **The core movement will produce AC signal output which will give the value and direction of inductance.**
- **LVDT (linear variable differential transformer) demodulator is used to convert the AC output to DC.**



Bellows Core Output Signal

iii. Diaphragm-capacitance pressure sensor

- The pressure is proportionate to the capacitance change at the output through dielectric change.
- Pressure from the sensor element causes the diaphragm to move towards the plate and produces dielectric change.



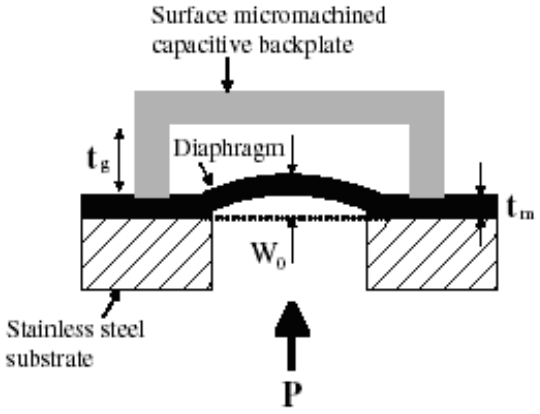
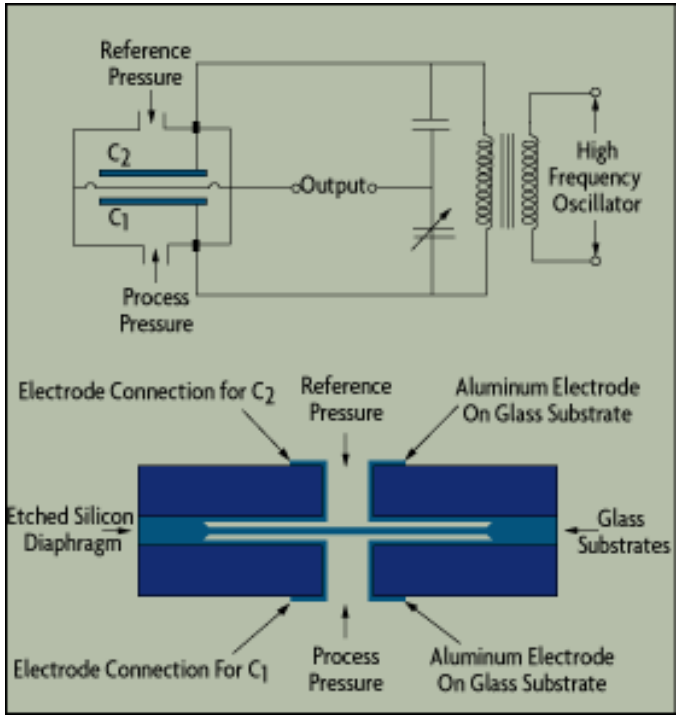
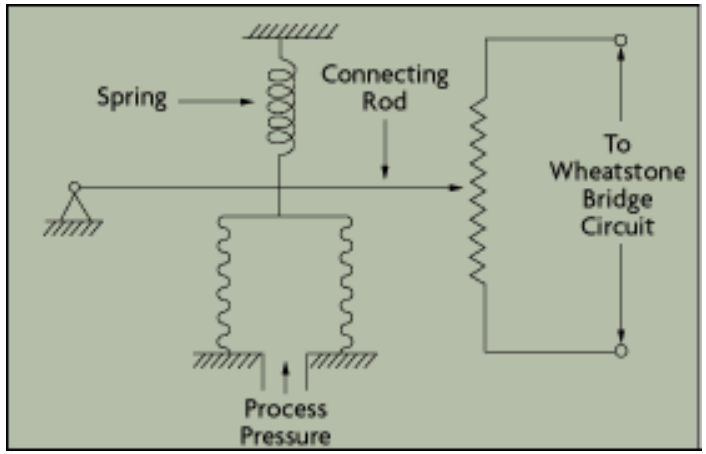


Figure 4. A schematic diagram of the side view of the capacitive pressure sensor.



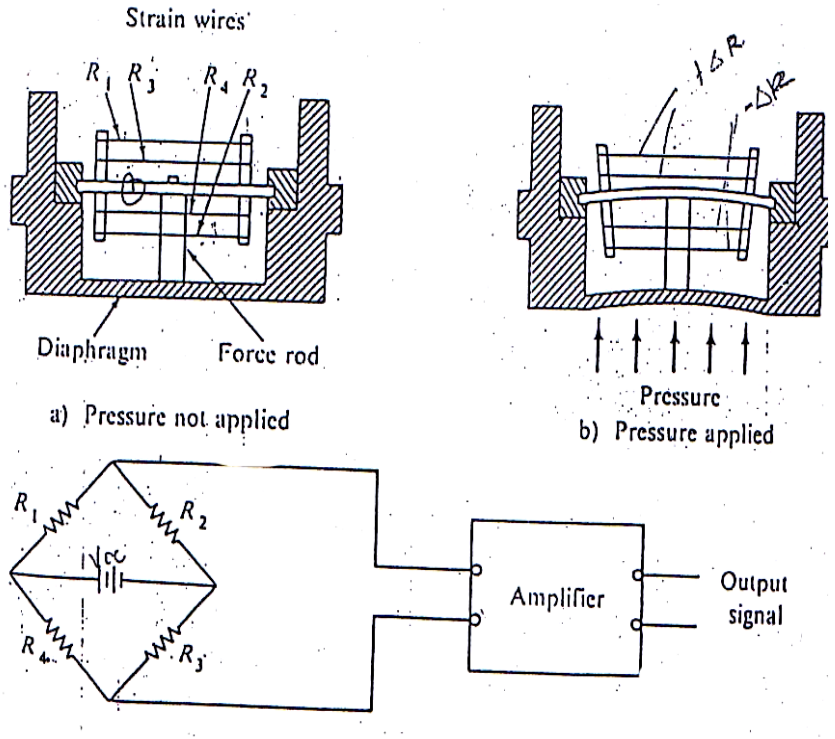
Capacitance Type

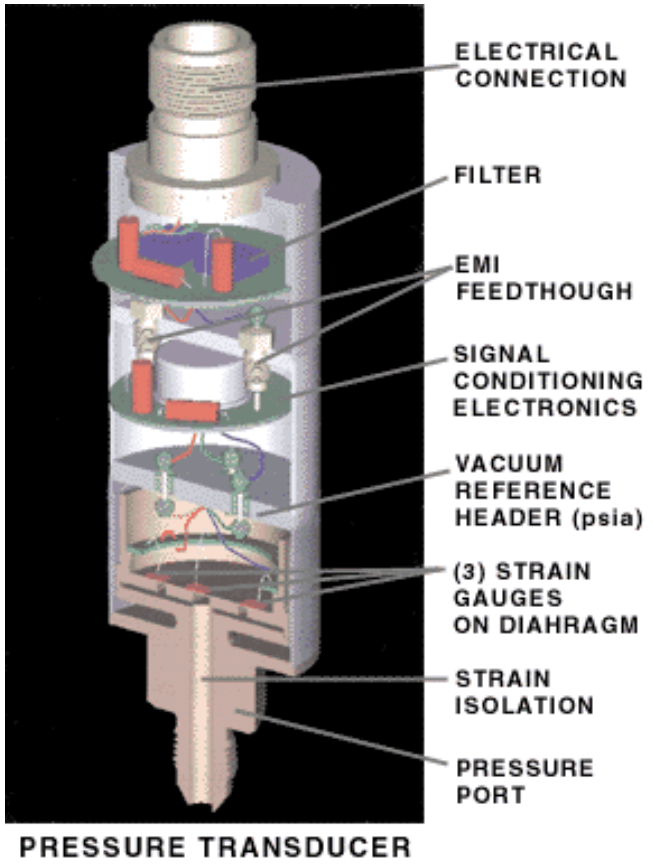


Resistance Type

2. STRAIN GAUGE PRESSURE SENSOR

- Strain gauge is a type of resistive transduction.
- Pressure measurement is obtained from displacement of elastic element.
- Pressure is measured through force that is exerted on the diaphragm where the force will be detected by the strain gauge and resistance change will be produced.
- Wheatstone Bridge circuit is used to detect the change in pressure and an amplifier is used to amplify the small output signals.



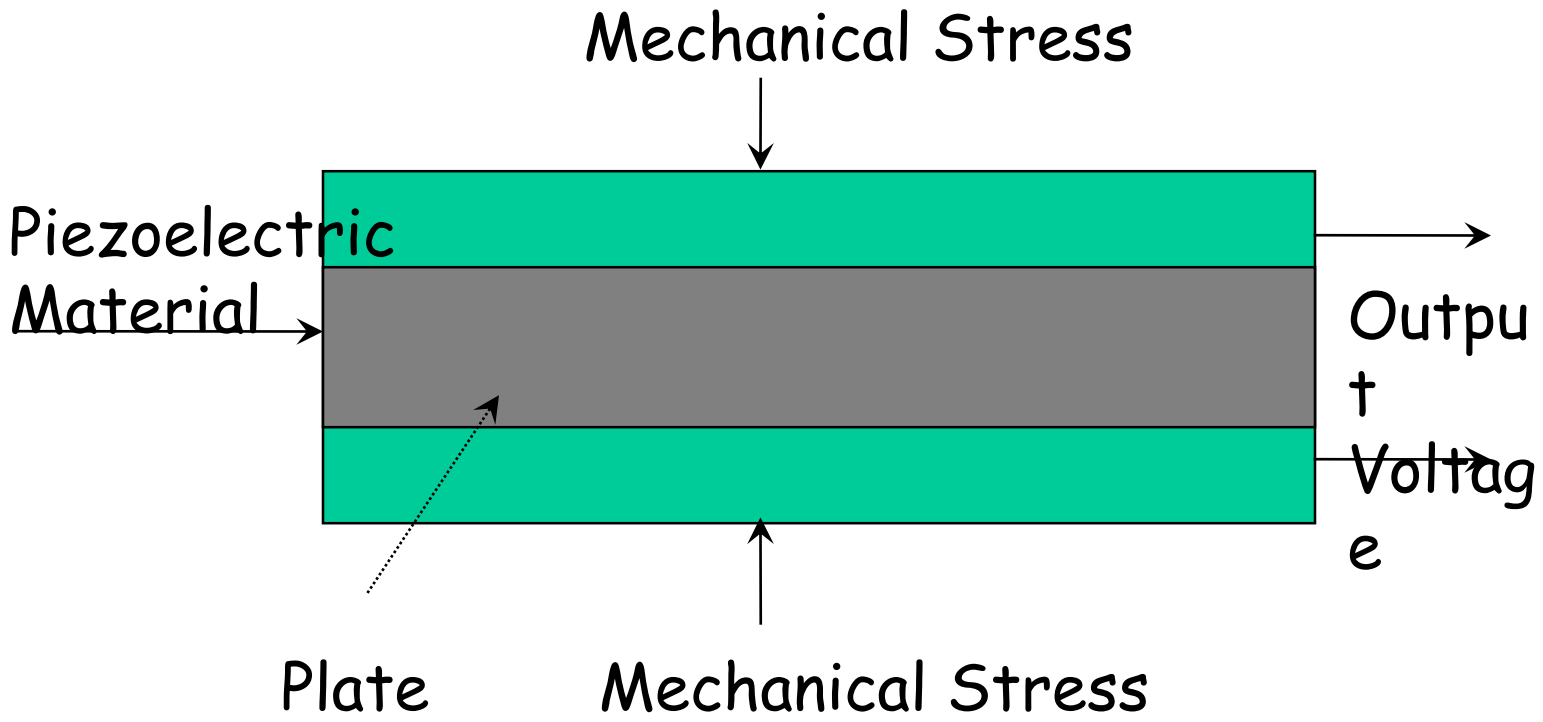


PRESSURE TRANSDUCER

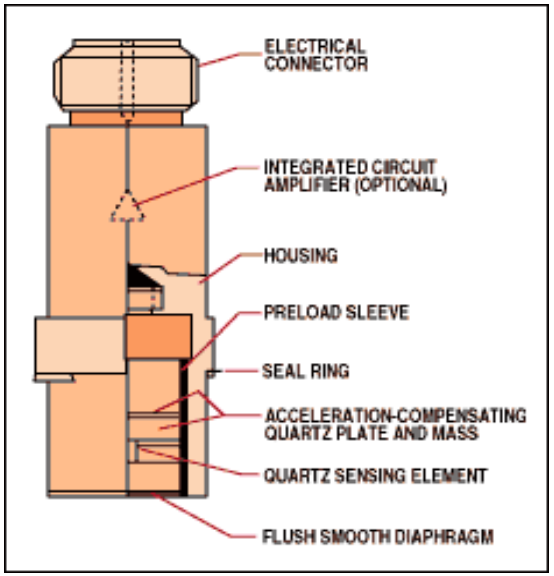
Strain Gauge Pressure Sensor

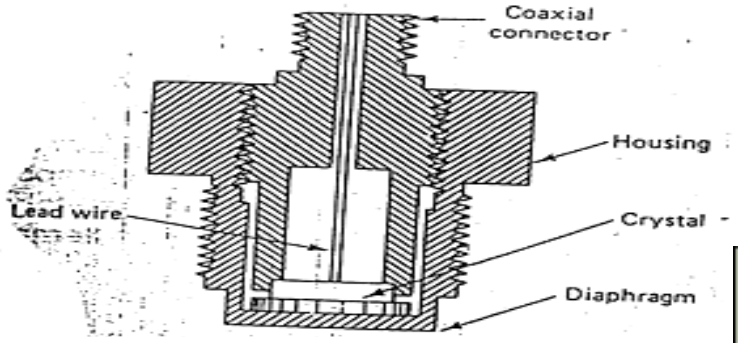
3. PIZOELECTRIC PRESSURE SENSOR

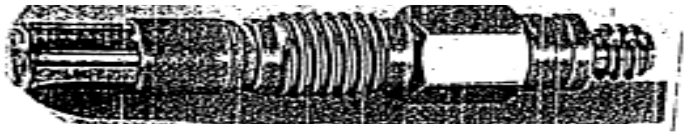
- This sensor consists of a piezoelectric crystal (made from quartz) which functions as a force-sensitive voltage source where the piezoelectric will be in between two plates.
- Pressure exerted on the crystal surface is proportionate to the voltage produced by the crystal.
- This sensor does not require any voltage supply.
- This sensor is suitable for fast changing pressure measurement.

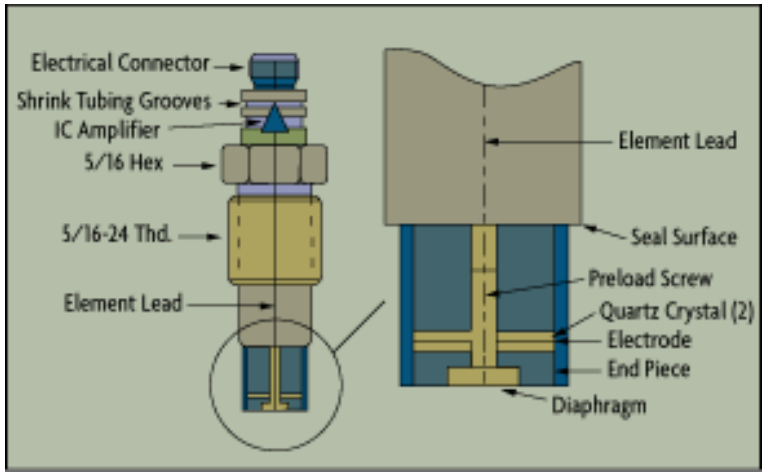


Piezoelectric Pressure Sensor









Piezoelectric Pressure Sensor