ETX → 5th

SENSORS

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(•) Motion Sensors →

· These sensors are used to sense / measure the motion related parameters like displacement, velocity, acc^{h}.

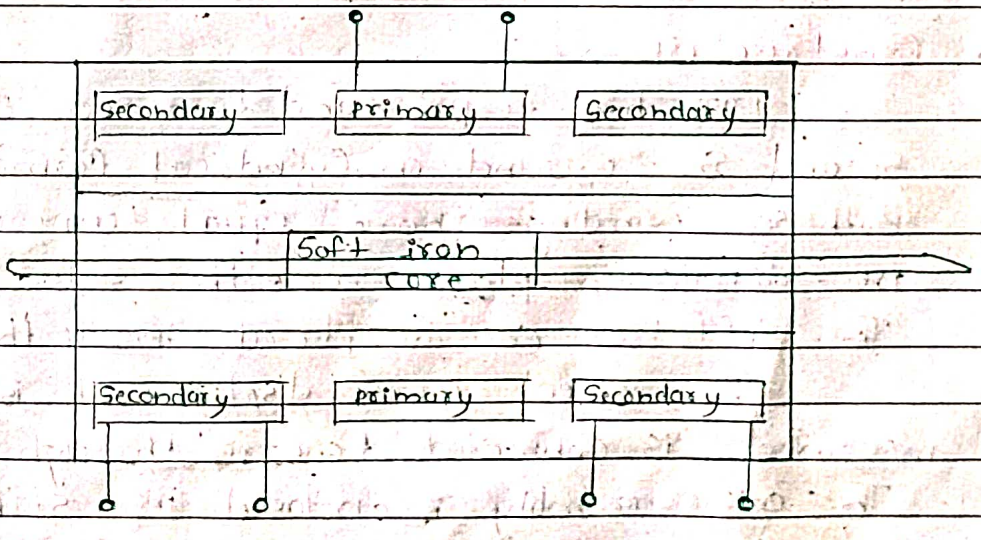
Sensors are available for linear as well as rotatary motion.

These sensors are used in security, ~~a~~ home control, and other useful sensors.

1). Linear Variable differential transformer → (LVDT) →

LVDT is a variable inductance displacement transformer

LVDT is ~~wed~~ widely used sensor for the measurement of linear displacement. It is a transformer with one primary winding and two secondary windings. It works on principle of voltage transformer (mutual induction).



ADV →

i) High accuracy 2) Very fine resolution
3) Very good stability ~~4) The transfer characteristic~~
5) Easy to fabricate and installation
6) It can operate at high temp.

6) High sensitivity.

DADV →

i) LVDT is sensitive to the ext magnetic fields. To minimize this effect maghetic shielding is necessary.

ii) Complicated circuitry is necessary

3) Due to mass of the core, LVDT is not suitable for measurement of fast displacement

4) Larger displacements are needed to get a substantial differential output.

Applⁿ →

- LVDT is used in measurement of pressure, load, acclⁿ, force, weight, etc.
- To detect the no. of currency bills dispensed by an ATM.
- To control weight and thickness of medical products.

Construction →

LVDT has a pri. and two sec. windings S_1 and S_2 wound on cylindrical former. Both sec. windings have equal turns and they are identically placed on either sides of primary. The soft iron core is placed inside the former.

The object whose displacement is to be measured is connected to core through arm. The entire assembly is enclosed in a stainless steel body with electromagnetic shielding.

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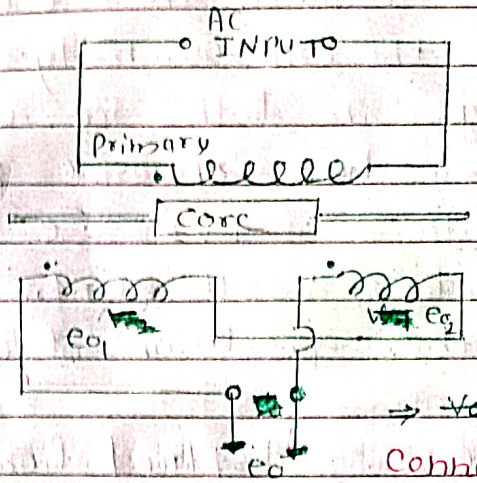
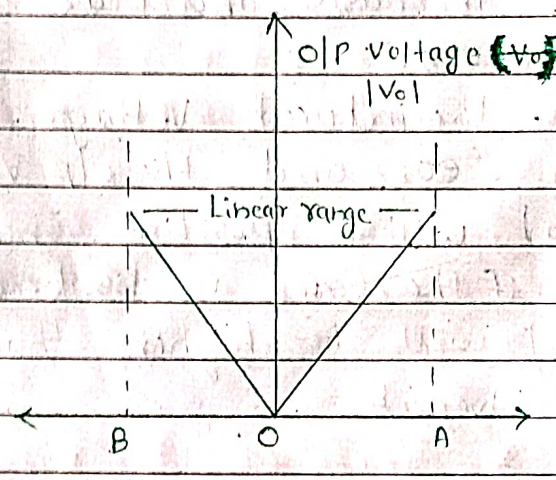
Working →

Two secondaries of ~~LVDT are connected in~~ series opposition.



Connecting of LVDT windings



Transfer characteristics of LVDT

- The moving obj, displacement of which is to be measured, is coupled to this movable rod.
- The two sec. winding are connected in series opposition. Therefore the voltages induced into these windings are of opposition polarities.

The o/p voltage is given by ~~Vo = Vs1 - Vs2~~ $e_o = e_{o1} - e_{o2}$

e_{o1} and e_{o2} are emf's induced in the two sec. windings.

The graph of o/p voltage against the core position is shown above.

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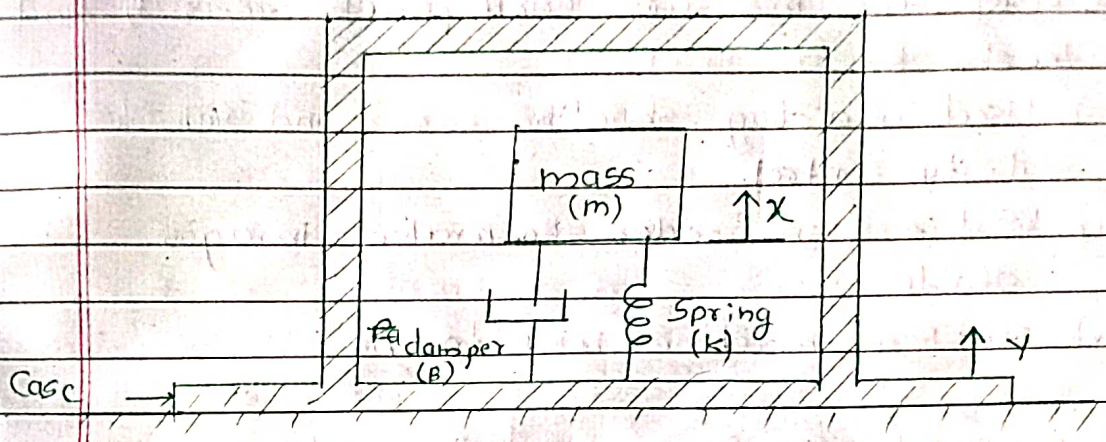
operation →

- The primary winding is connected to ac source.
- Assume that initially the core is exactly at the centre of the coil assembly. The induced voltages in both sec. windings are equal but they have opposite polarities.
- The o/p voltage of LVDT 'e₀' is therefore zero corresponding to the central position of the core. this position of core is called as 'null position'.
- Now if the core is displaced from its null position towards sec. 1 then the flux linked to sec. 1 increases and flux linked to sec. 2 decreases.
- Therefore, the induced voltage (e_{o1}) is now higher than 'e_{o2}' and the o/p voltage of LVDT (e_o) will be positive.
- Similarly if the cores is displaced downwards then (e_{o2}) will be higher than (e_{o1}) and o/p Vltg is negative.

2). Accelerometer →

An accelerometer is a sensor that is used to measure acceleration of an object. It is also used for measurement of Vibration, shock. The basic ~~of~~ accelerometer sensor is mechanical system with mass, damper and spring. Such arrangement is known as seismic instrument.

- Construction →



The accelerometer consist of mass, damper and spring. ~~as~~ The mass is suspended freely and is connected to casing through damper and spring. The mass-damper spring assembly is enclosed by a casing.

- Working →

Due to appln of force the accln takes place. Hence, mass-damper-spring experiences a displacement x and the casing experiences a displacement y. Thus relative displacement is x-y.

Thus by measuring x with displacement sensor attached to mass and knowing all constants (K = spring const, m = mass, B = Damper const) the accln can be measured.

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- Applⁿ →
  i) Used to measure earthquack activity and aftershocks.
  ii) Used in airbag shooting cars and Vehicle stability Control.
  iii) Used in camcorder to make images stable.
  iv) ~~For~~ For machine monitoring

⊙ Tempreature Sensors | Transducers →

The Sensors that change their o/p with change in temp. are called tempreature sensors.

Ex → Thermocouple, RTD, thermistors, pyrometers.

1) Resistance type tempreature sensor (RTD) →

~~Generally, electrical resistance of any metallic conductor varies according to temp. changes.~~

RTD is defined as the temp. sensor whose resistance changes in proportion with its temp.

- principle →

The resistance of conductor changes when its temp changes; this prop. is used for the the measurement of temp. The RTD determines the change in the electrical resistance of the conductor to determine the tempreature

The relⁿship betⁿ temp. & resistance of conductor is given by,

$$R_t = R_o (1 + \alpha_o \Delta t)$$

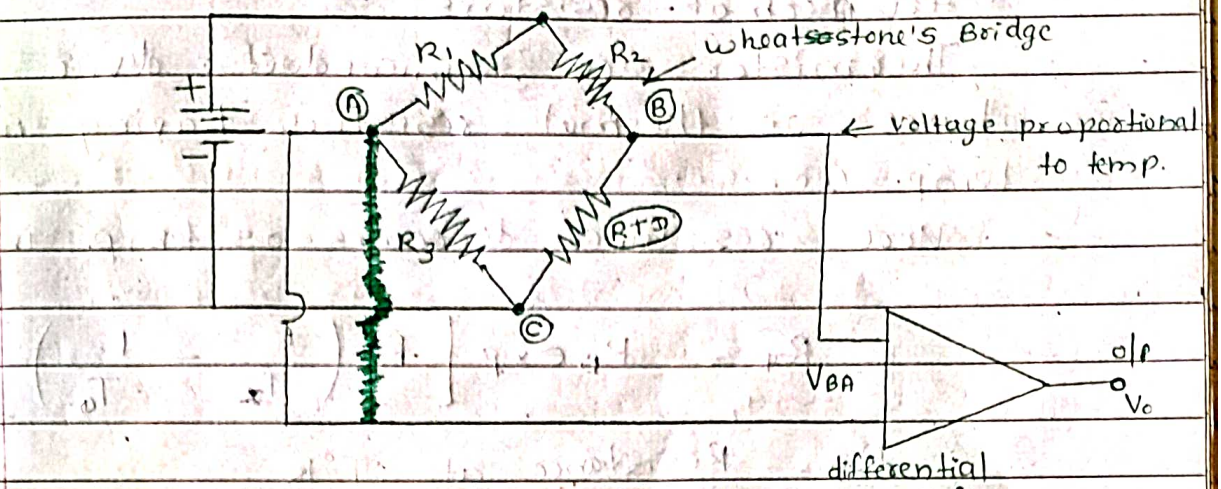
R_t = Resistance of conductor at t°C.

R_0 = Resistance at room temp to.

α_0 = temp Coe. of resistance (resistance) at 0°C.

ΔT = Temp. diff. (temp to be measured & referance temp).

Construction →



— The Voltage at point A is given by the following exp. and it always remains const. →

$$V_A = \frac{R_3}{(R_1 + R_3)} \times V_s.$$

— The Vltg at pnt B varies with variations in the temp.

— The differential Vltg V_{BA} is amplified by a differential amplifier. ∴ The variation in the o/p Vltg V_o is proportional to changes in temp.

ADV →

i) High accuracy ii) Wide temp range (−200°C to 650°C) iii) Used for measurement of small as well as large temp differences

iv) Good dynamic response.

v) No need of temp. compensation.

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DISADV →

i) large size ii) high cost iii) Ext dc power soura is required. iv) Low resolution (of the order of 7 ohms/°c.)

2) Thermistors →

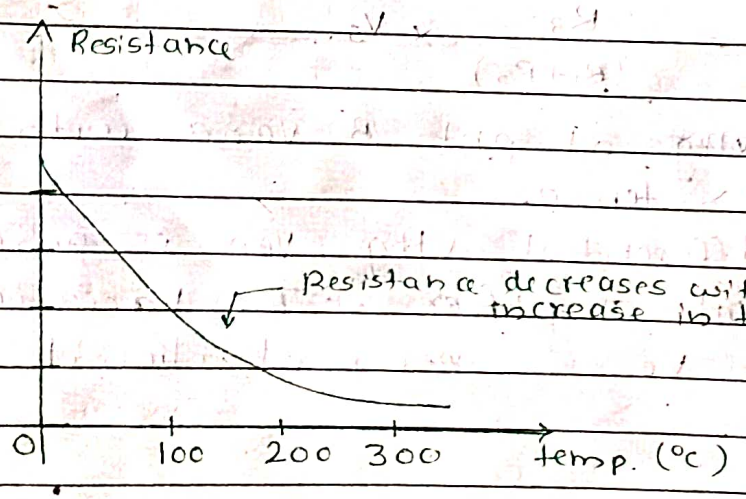
- Thermistor is a Contraction of term 'ter thermal-resistors'.
- Thermistor are semiconductor device which behaves as thermal resistors having negative temp. coe.
- Here resistance decreases as temp. increases.

$$R_T = R_0 \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$

R_T = Resistance at T°k

R_0 = Resistance at known temp T_0°k

β = material Const (char. temp)



- This shows that the variation of resistance with changes in temp. is non-linear.
- As resistance decreases with increase in temp, this is called as negative temp. coe. thermistor.

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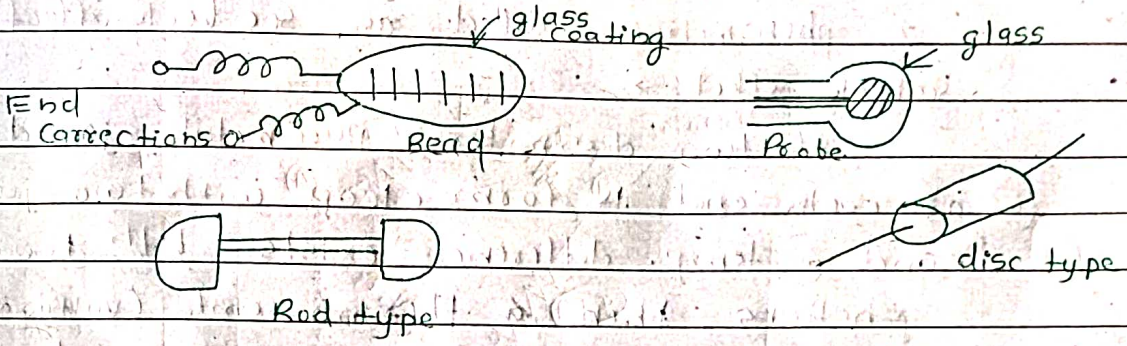
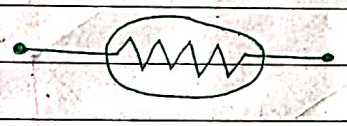
- Construction →

Thermistors are constructed using the materials such as sintered mixtures of sulphides, selenides, oxides of manganese, nickel, cobalt, iron, copper etc.

They are available in various configurations such as small beads, discs, rods.



Configurations of thermistors



→ symbol.

- ADV →

i) They are suitable for precision temp measurements, temp control and temp. compensation.

ii) High resolution

- DADV →

i) Temp Versus resistance characteristics is non-linear.

ii) Not suitable for wide range operation

iii) Needs ext dc power supply for its operation

- Applns →

i) As a temp. sensor with or without compensation

ii) In biomedical instrumentation

3) In measuring the temp. distribution or temp. gradient.

3) Thermocouples →

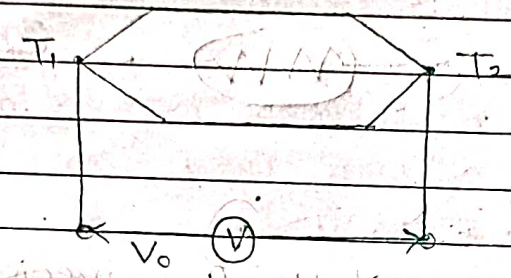
Thermocouple is an active temp sensor which produces an emf proportional to the temp diff beth two junctions.

- principle →

The operation of thermocouples is based on a phenomenon called as seebeck effect.

seebeck effect →

If two dissimilar pure metals joined together at each end to form a loop with two junctions and a temp. difference exists beth two junctions then a thermo-emf (voltage) proportional to temp. difference is generated.



$V_0 \propto (T_2 - T_1)$

$V_0 = C(T_2 - T_1)$

where, C = Sensitivity of thermocouple in mv/°C or uv/°C

∴ By ~~measurement~~ By measuring o/p voltage across the junction the temp. can be determined.

- Construction →

The two dissimilar metals are joined together to form two junctions. The thermocouple junctions are placed in protective casing of Stainless steel and o/p terminals are made available for V/tg measurement.

One of the thermocouple junction is kept as reference junction (J_1) and other is considered

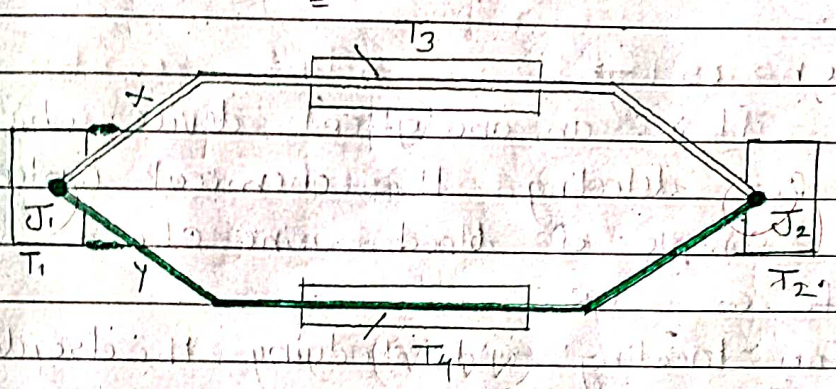
as measuring junction (J_2). The reference junction is kept at ambient temp T_1 and measuring junction is exposed to chamber (kept in a) whose temp. is to be measured. Then due to temperature difference the thermo emf voltage V_o is generated:

$$V_o = c(T_2 - T_1)$$

$$T_2 = \frac{V_o + cT_1}{c}$$

$T - T_2$

=



- Material used for thermocouple →

Type

i) Copper - Constantan alloy : 0 - 2000° F
ii) Iron - Constantan alloy : 0 - 1200° F
iii) Platinum - Rhodium alloy : 0 - 3000° F
iv) Chromel - Alumel alloy : 0 - 900° F.

- ADV →

i) wide temp range (-200°C to 1100°C)
ii) Ext dc source is not req.
iii) good sensitivity. (small changes in temp can be sensed)
iv) Fast dynamic response (responds quickly to any temp changes)

- DADV →

i) The temp. emf characteristics of thermocouple is slightly non-linear.
ii) The small generated emf is small. therefore amplification is req to be provided
iii) Cold junction compensation needs to be done for

accurate measurement of temp.

- Appln →

Thermocouple are most suitalle for temp measurement of industrial furances. They are used in appln where →

i) wide operating temp range is req.
ii) Temp at remote places are to be measured
iii) ~~Temp~~ High response is req.

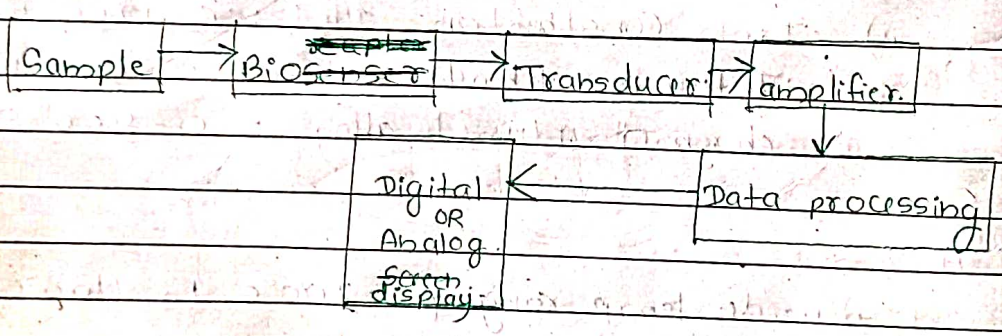
⊙ Biosensors →

It is an analytical device which is used for detecting the chemical contents of a sample of blood, urine etc.

~~fo or~~ OR

for locating and studying the disorder of a physical organ like brain, heart, eyes, lever etc.

- BD →



- Bioreceptor → The bioreceptor is in the vicinity of smpl. Depending on the smpl and its conc. the prop. of bioreceptor changes.
- ~~The bioreceptor can be enzyme~~

- Transducers → Transducers converts one form of signal into another form. In this case, the change in prop. of bioreceptors is converted into electric signal.

- Amplifier →
  The electric signals produced by transducer are very weak. Hence the o/p of transducer is amplified using amplifier.

- Data processing →
  The amplified electric signal is calibrated against composition and conc. of smpl.

- Display →
  The final o/p is shown on the screen.

- Biosensor →
  It detects the contents of the smpl or damages in the organ of a body. and i/p to a transducers
  It is in the form of electron microscope, X-ray machine.

- Applns →
  i) common healthcare checking
  ii) metabolities measurement
  iii) Insulin treatment
  iv) ~~drug~~ + clinical Psychotherapy,
  v) and diagonosis of disease.
  v) Drug improvement
  vi) Ecological pollution control.

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⊙ optical sensors →

The OS are sensitive to light. The electrical prop. of these sensors change with the intensity of light falling on them.

The following OS are commonly used →

1] photo diode 2] photo transistor } photo conductive devices

3] photo voltaic cell 4] photo multiplier ~~cells~~ tube

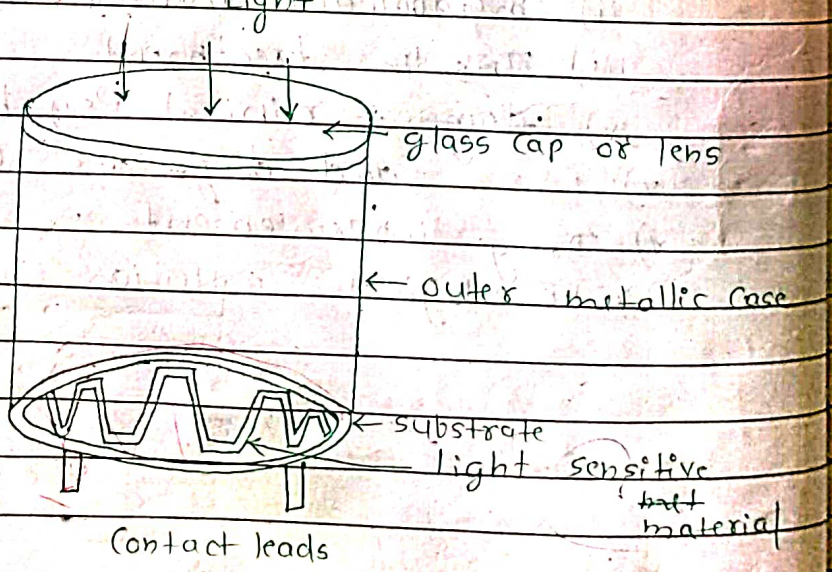
5] Light dependent resistor (LDR).

• LDR → Light dependent resistor →

LDR is a device whose resistance depends on the intensity of light falling on it. It is also called as photo resistor.

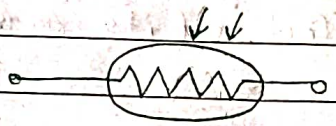
• principle → LDR is a two terminal device. It works on the principle of photoconductive effect and its resistance decreases with increase in the intensity of light.

• Construction →



A light sensitive material such as Cadmium Sulphide (CdS) is deposited on a ceramic substrate

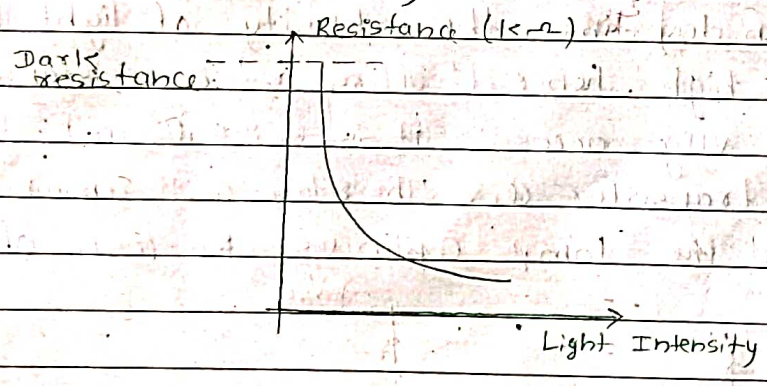
Then the substrate along with the photosensitive layer of Cds is enclosed in a metal container. Contact leads are brought out for ext connections.
- light is incident on the light sensitive material through the glass cap or lens which has been added at the top of this assembly.



→ Symbol

- working →

LDR is made up of semiconductor material with high resistance. It has high resistance becz there are very less free electrons and majority of electrons are locked into the crystal lattice structure, when the light falls on the LDR, the photons are absorbed by the active layer region. The energy of absorbed photons is transferred to electrons locked into the crystal lattice. This energy makes the electrons free to move which allows conduction of electricity. Due to this action, the resistivity of LDR falls.



The resistance of LDR when no light falls on it is called as dark resistance.

- ADV →

1) Simple to construct and operate
2) good sensitivity
3) Low cost
4) Linear response

DADV →

i) Slow working. (resistance does not change quickly)

ii) It can work only in a small range of electromagnetic spectrums.

iii) It has a light memory effect or light history effect. (its resistance changes slowly)

Appl^ns →

i) parking light on/off system

ii) In security alarm sys.

iii) To check the intensity of light

iv) ~~tow~~ street light control.

v) ~~A~~

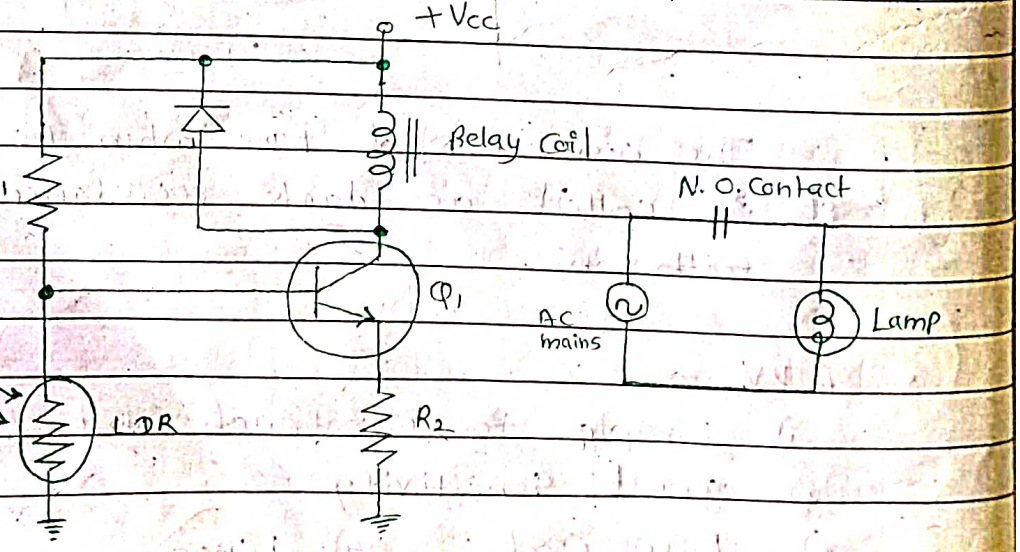
Photo relay using LDR →

LDR can be used in automatic on off switch circuit used for the street lights. This is also called as photo-relay circuits.

operation →

In day time, the intensity of light falling on LDR is high, hence it offers a low resistance.

The vltg across it is not sufficient to turn on the transistor Q_1. The relay will remain unenergized and the lamp continues to be in off state.



In evening, light intensity reduces. the resistance of LDR increases, therefore, Voltage across it will be large enough to turn on the transistor. The relay will be energized and N.O. contact gets closed to turn turn on the lamp.

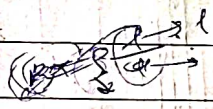
This is called as photo relay circuit bcz its operation is Controlled by intensity of light.

⊙ Mechanical Sensors →

- Strain gauge →

Strain gauge is a passive, resistive sensor which converts the mechanical elongation and compression into a proportional resistance change.

Strain gauge is widely used for the measurement of strain, pressure, force and weight.



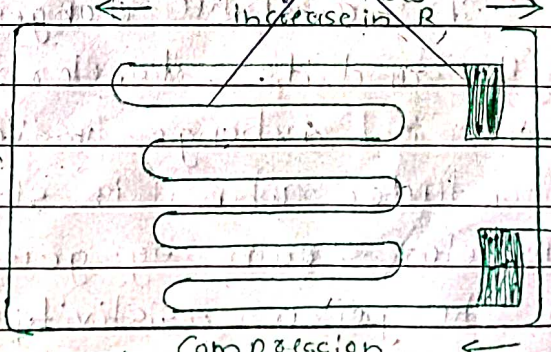
- Principle →

Resistance of any conductor depends on its resistivity, length and cross sectional area. Hence if there is change in length or cross sectional area due to compression or elongation, resistance gets changed.

- Types →

1) Wire gauges →

i) Unbonded ii) bonded iii) Foil type.



operating principle of strain gauge

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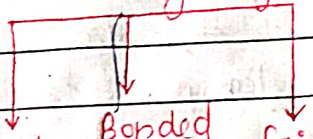
Two types

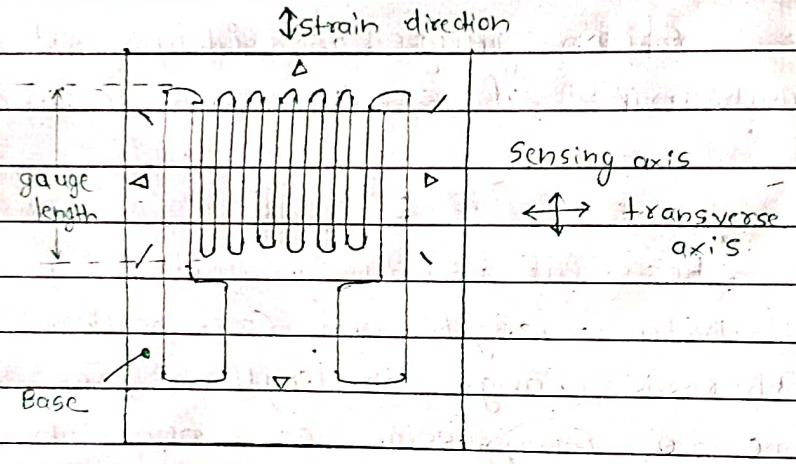
1) wire guages →



i) Foil strain gauges →

The FSG is basically an extension of the wire guage in principle but it is different in its constructional features.

The material used for foil gauges is same as that of wire gauges.



Foil strain gauge

2) Semiconductor strain gauge →

Principle →

If a metal conductor is stretched or compressed ; its resistance changes due to change in its length and its diameter.

- Similarly there is a change in value of resistivity of a semiconductor when it is strained. (peizo resistivity)
- The semiconductor strain ~~ag~~ gauges operate on the peizo resistivity property of doped silicon and germanium.

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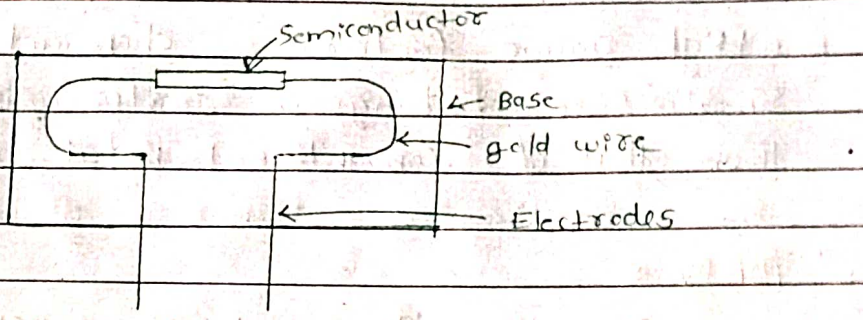
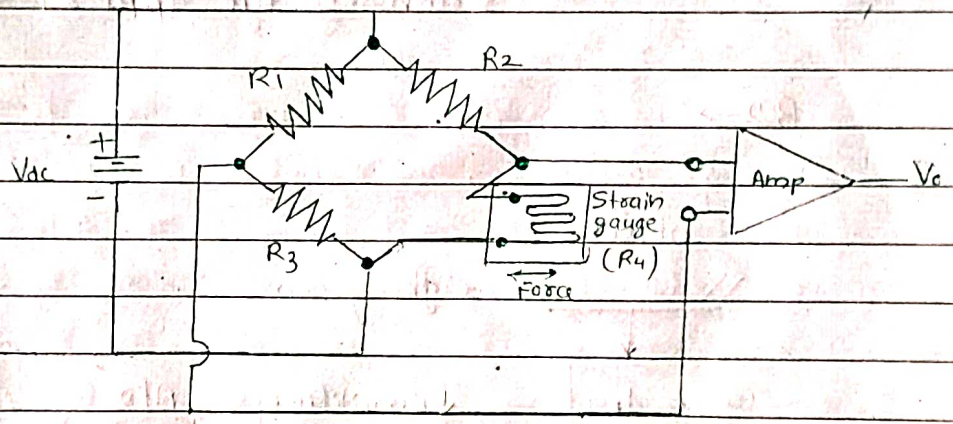
Construction →



Semiconductor strain gauges are fabricated from single crystals of silicon and germanium. The resistance of semiconductor gauge changes mainly due to the changes in the resistivity of the semiconductor material, itself.

Working →



- In order to use the strain gauge as a practical instrument, we must measure extremely small changes in resistance with high accuracy.
- This can be achieved by using a bridge circuit as shown in fig. The o/p Vltg is prop. to the amnt of stress.
- In practical applns, a single strain gauge is generally not used. Instead either two or sometimes four strain gauges are connected in bridge. This increases its sensitivity twice or four times respectively as compared to a single gauge.

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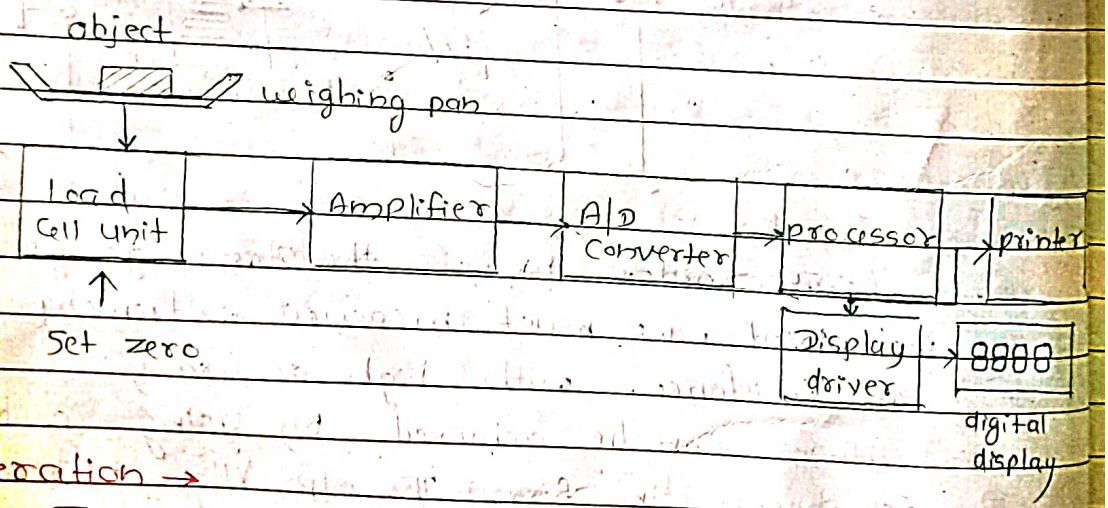
- ADV →
  High gauge factor, chemical inertness, Small size, change in resistance is much higher than that of Conventional metal alloy types.
- DADV →
  poor linearity, more expensive, Sensitivity to changes in temp.
- Appl^ns →
  preassure measurement, weight measurement etc.

⊙ Electronic weighing machine → (Strain gauge appl^ns) →

BD →



- operation →
  The weighing pan is in direct contact with load cell unit. The load cell unit contains strain gauge sensor / Transducer which Convert the weight into electrical o/p.
  - The zero setting adjustment is provided along with the load cell unit.

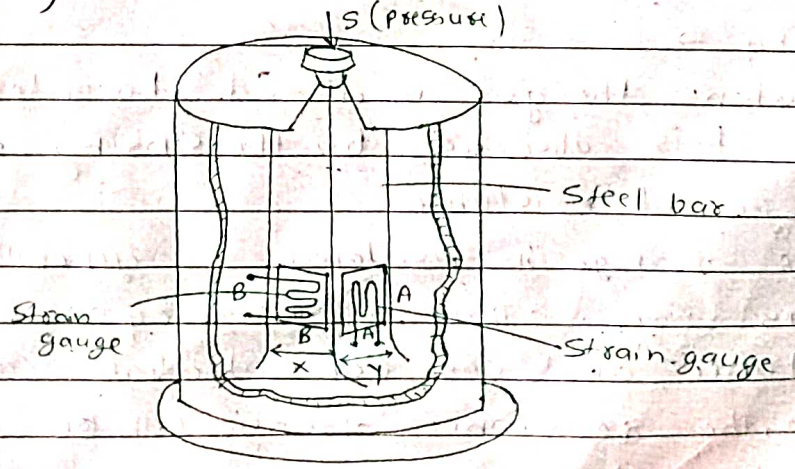
- The electrical o/p of the load cell unit is amplified by the amplifier and converted into a digital signal using an A/D Converter.
- The processor can be a microprocessor or a microcontroller. It processes its input data, stores it in a memory, calculates the exact part price of the item and sends it out.
- This data is then applied to a pointer and digital display unit through a display.

⊙ Load Cell (pressure Cell) →

Load cell is used for weighing extremely heavy loads. It uses strain gauges for measuring weight.

- The weight is applied along the direction shown by the arrow. Due to this stress, steel bar gets compressed along axis S and expands along the x-y axes.
- Due to this, the resistance of strain gauge A will decrease and that of strain gauge B will increases.

This arrangement makes the load cell very sensitive to detect small values of applied stress and it can measure very heavy loads as well.



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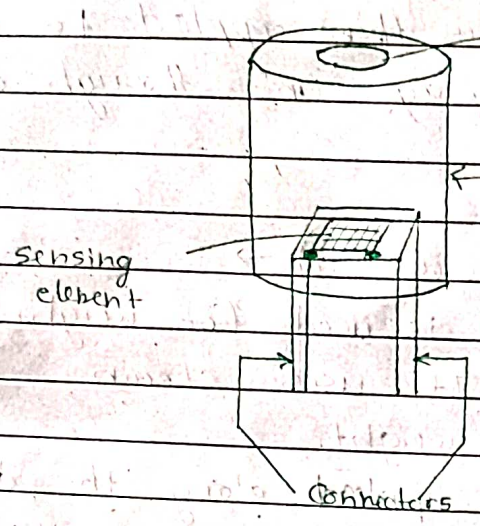
⊙ Semiconductor gas sensor →

Pain →

Semiconductor gas sensors rely on the gas coming into metal oxide surface and then undergoing either oxidn or redn.

Cons →



It Consist of a metal oxide film as a sensing element. The exact metal depends upon the gas to be detected. The film is connected to electrodes and from electrodes the connecting wires are taken out for measurement of resistance. This sensing element is covered with a sensor body having sensor cap and a filter.

Working →

when the gas is allowed to enter the sensor body, it is absorbed by the sensing element which changes it resistance.

The change in resistance is generally proportional to gas conc. Thus a linear eqn between resistance and gas concentration can be established. Also the resistance change can be converted into V/I/g using electronic circuit.

Applns →

The gas sensors are generally used for detection of CO, CO_2, methane, propane, oxygen. Accordingly the material of sensing element is selected.