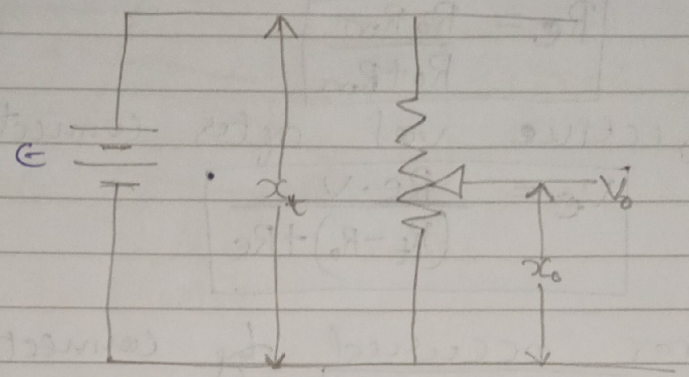
Module I

(R) → resistance
(T) → transducer

SENSORS AND TRANSDUCERS.

→ * potentiometer =



x_t → total resistance
V_o → ഔട്ട്പുട്ട് voltage-ന്റെ അളവ് ഇത് നിശ്ചയിക്കുന്നു
x_o → അതിന് corresponding ആയിട്ടുള്ള R അളവ് R_o.

* x_t → total length b/w 2 endpoints ഉം (R). b/w these 2 end points are always constant.
* output vol → $V_o = \frac{x_i E}{x_t}$
* If V is the excitation vol, then output vol V_o,

$$V_o = \frac{x_o}{x_t} \cdot V.$$

In R form, $V_o = \frac{R_o}{R_t} \cdot V.$

→ * Loading effect on (P) =

* output vol of (P) is generally connected to input of amplifiers / measuring device.
* input (R) of amplifier also effect the vol b/w slider contact & ground.
* This effect is → loading effect of (P)

* If the input R of connected meter is R_m & R between sliding point & endpoint is R_0 then total effective R is given by,

$$R_e = \frac{R_0 R_m}{R_0 + R_m}$$

* The effective val after connecting the load,

$$V_e = \frac{R_e \cdot V}{(R_t - R_0) + R_e}$$

* The error occured by connecting the load,

$$E = \frac{V_e - V_0}{V_0}$$

⇒ Resistence Strain gauge (S.g) =

* R.S.g is an imp (t) making use of (r) variation as a fundamental property.
* Resistance of a wire,

$$R = \frac{\rho l}{A}$$

ρ → resistivity of material

(ಇಲ್ಲಿ element ಆಧರಿಸಿ (Cu, Al, Si...) ಇದರ ρ ಬದಲಾಗುತ್ತದೆ)

l → length of the material

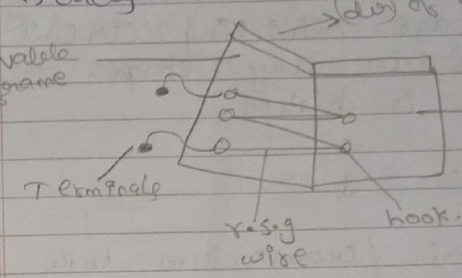
A → area of cross section.

* when a material is under strain, some of these params may change.

* Gauge factor = the ratio of change in (r) to change in (l).

* Types of S.g =

1) Unbounded S.g = S.g which are not directly mounded on the obj under study.



* It is separate from the str & can be transported from 1 str to anthr.

2) Bounded S.g = the S.g is directly mounted to a frame.

* 3 types →

a) Fine wire S.g =

* Here a fine r. wire is bent like a spring & packed in a paper / plastic bag.
* Any pressure applied on it changes its dimension & hence its (r) changes.
* eg → Ni (Nichrome) – 80 %
  Cr – 20 %.

(adv) * high accuracy & linearity
(disadv) * costly & not be reused.

b) Metal foil S.g = Here, (r) metal foil is printed on a nonelectrical base material like PCB. (printed circuit diagram) design.

* when the force applied on the gauge,

its dimension varies & hence the (R) too.
* Change in (R) can be measured by using a voltage dividing circuit.

(adv) * manufactured in any shape.
* sensitivity is higher.

c) Semiconductor S.g =

* made up of Si / Germanium type S.cond materials.
* when a ~~stress~~ force is applied on this S.cond, its (R) change in accordance with the applied force.
* Hence (R) of S.cond also changes with applied strain.
* Also → piezo (R) (t).

(dis) * costly & poor linearity.

(adv) * small size & get freq response upto 10^{12} Hz.

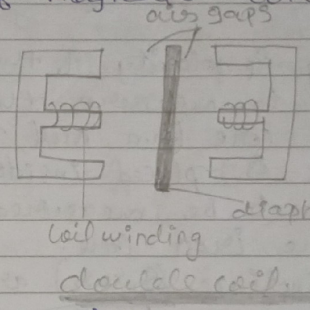
⇒ Inductance (T) =

→ Principle →
* I.(T) uses 1 of the follow principles.—
a) Change of self-inductance
b) Change of mutual "
c) Change of eddy crnt.

* It is used in the measurement of force.
* The change in the I. ratio of a pair of coils / by the change of I. in a single coil indicates the mag of force.

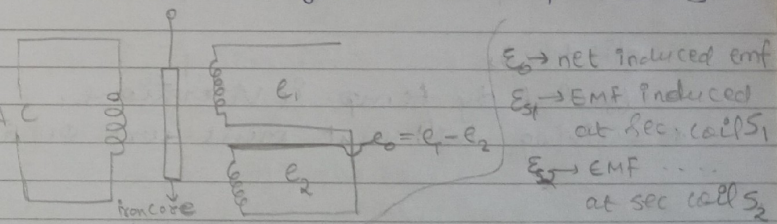
* output of active (t) depends on signal which is used for measurement.
* output of passive (t) depends on signal from ex. power supply.

* The armature will be displaced by the applied force.
This causes variation in the reluctance of magnetic circuit.



⇒ Linear Differential Transformer (LVDT) =

* most widely used I.(T) to translate linear motion into electrical signal.
* It is a passive (T).[(t) which require an ex. power source for their operation].



circuit of LVDT

total emf → $E_0 = E_{S1} - E_{S2}$

Output val of sec coil → S_1 & S_2.

working →

① Correct center ⇒ $E_{S1} = E_{S2}$

$E_0 = E_{S1} - E_{S2} = 0$ (no displacmt)

$E_0 = E_{S1} - E_{S2}$

(core is moved to downward of null position)

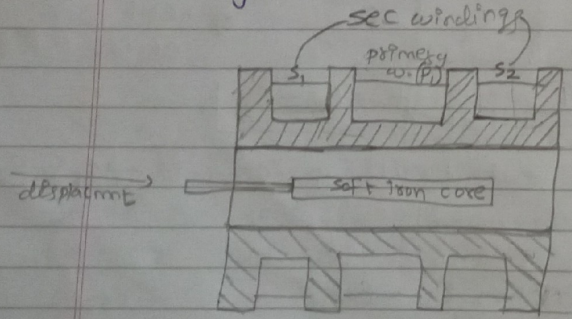
② core at right ⇒ $\varepsilon_{s1} < \varepsilon_{s2}$.
$\varepsilon_o = \varepsilon_{s1} - \varepsilon_{s2} = -ve$,

③ core at left ⇒ $\varepsilon_{s1} > \varepsilon_{s2}$
[core is moved to upward of null position] $\varepsilon_o = \varepsilon_{s1} - \varepsilon_{s2} = +ve$

* LVDT uses the mag & polarity of the net EMF induced to measure the displacemnt of its core from null position.
* A movable iron core is placed inside the former & displacemnt to be measured. is connected to the iron core.
* Both secondary windings (S_1 & S_2) are connected in such a way that resulted output is the diff~ b/s vol of 2 windings.

Adv →
* gd linearity, sensitivity
* High input & high range.

dis Adv →
* affected by temp. & vibrations.
* receiving instrumnt must work on AC.

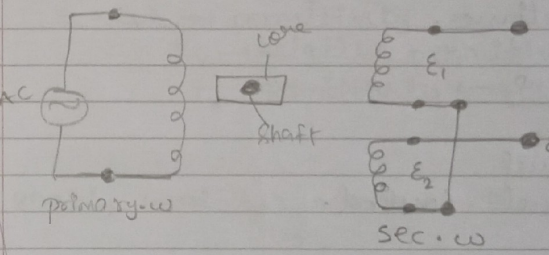


LVDT

⇒ Rotary variable Differential Transformer (RVDT) =

* (T) which senses the angular displacemnt of the conductor → RVDT
* It is a type of electromechanical (T) which gives the linear output proportional to input angular displacement.
* working of RVDT is similar to LVDT.
* only diff is that the LVDT uses soft iron core for measuring displacmnt, RVDT uses the cam shape core rotated b/w the primary & sec winding with the help of shaft

Construction



RVDT construction

* working = (3 cases)

case 1:- when core is in null position, output vol of sec. w S_1 & S_2 are = & opp~

$\varepsilon_1 = \varepsilon_2$ ∴ $\varepsilon_o = 0$.
(no disp).

case 2:- core position is towards the S_1 w of sec. (clockwise dir)

$\varepsilon_1 > \varepsilon_2$
∴ $\varepsilon_o = +ve$

case 3 :- core position is towards S_2 & of sec. (anti-clockwise (clk)).

$\varepsilon_1 < \varepsilon_2 \quad \therefore \varepsilon_0 = -ve.$

Adv →
* Low cost
* Durability
* linearity is excellent.

Disadv →
* output of RVDT is linear
* contact among the measuring external as well as the nozzle is not possible for all time.

Applications →
* Robotics
* Controls fuel
* Engine fuel control.

⇒ Capacitive (T) =

* used for measuring the displemnt, pressure & other physical quantities.
* It is a passive (T) that means it requires ex. power for their operation.
* C-(T) works on the principle of variable capacitance.
* The capacitance of (C.T) changes bcz of ① overlapping of plates
② change in distance b/w plates
③ " dielectric constant.

* In normal capacitor the (dis) b/w plates are fixed, bt in C.(T) the (dis) b/w them are varied.

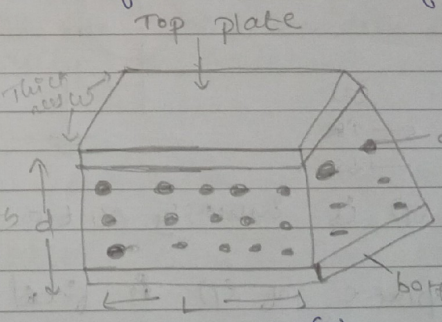
principle →

P. of operation of C.(T) is based upon the families eq for capacitance of a parallel plate capacitor.

capacitance, $C = \frac{\varepsilon A}{d}$ or $C = \frac{\varepsilon_r \varepsilon_0 A}{d}$.

A → overlapping area of plates
d → (dis) b/w 2 plates
$\varepsilon = \varepsilon_r \varepsilon_0$ ⇒ permitivity of medium.
ε_r → relative permittivity
ε_0 → permittivity of free space (8.85×10^{-12} F/m)

* mainly used for measuremnt of linear displemnt.

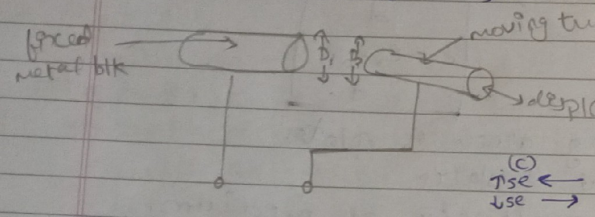


parallel plate C.(T)

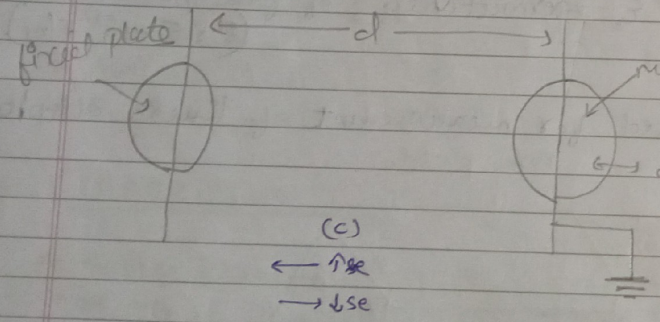
* 3 changes in C.(T) =
a) (T) using the change in the area of plates=

C → capacitance

* Examining the eq of (c), $C = \varepsilon_r \varepsilon_0 A/d$ it is found that the (c) is directly ∝ to the area, A of the plates.
* Thus (c) changes linearly with change in area of plates.
* Hence this c.T are used for measuring the large displcmnt approximately from 1mm to several cms.



b) (T) using change in (dis) b/w plates =



* (c) of the (T) is inversly ∝ to (dis) b/w plates.
* The one plate of (T) is fixed & the other is movable.
* The displcmnt which is to be measured links to the movable plates.

(c) (T) using change in dielectric constnt =

* A c (T) may use the principle of change in dielectric constnt to achieve variable (c).
* (c) of parallel plate capacitor is directly ∝ to dielectric constnt (ε) for a given plate area & separation.

* sesitivity of c (T) =
sensitivity of the capacitor for change in (dis),

$$S = \frac{\partial c}{\partial x} = \frac{\varepsilon A}{x^2}$$

x → displcmnt.

* Adv →
* low cost
* low power required
* High resolution.

Disadv →
* Non linearity
* Affected by dirt, humidity, etc.
* Sensitivity to noise.

Appli →
* linear & angular measurmnt.
* Force & pressure.
* Humidity in gas.