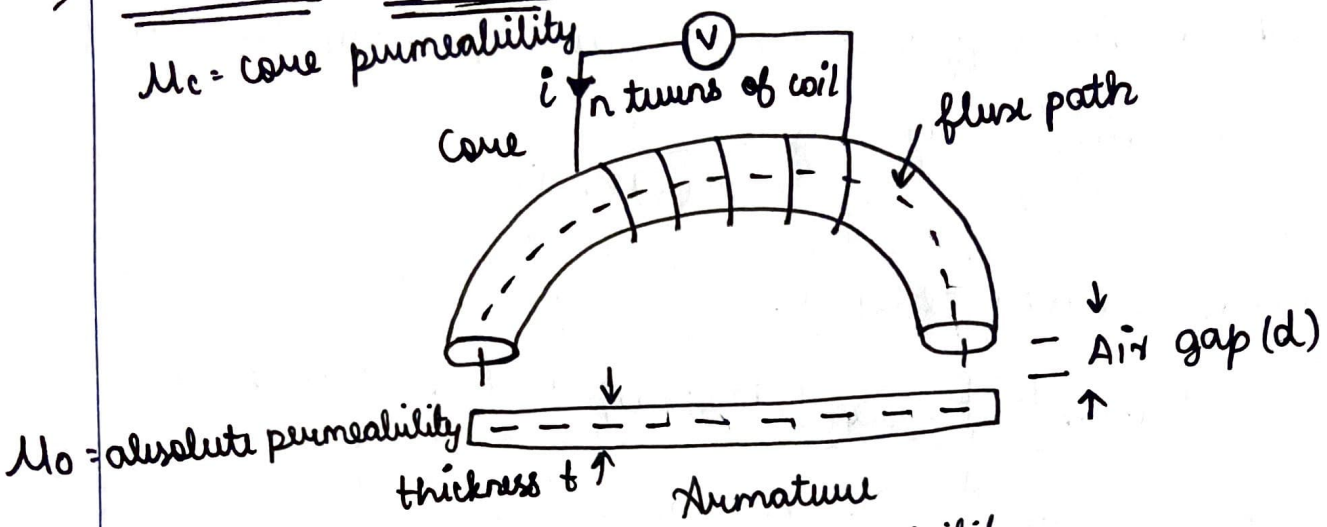
3) Inductive Sensors :-



★ uses the principle of Electromagnetic Induction to measure objects

★ An inductor develops a magnetic field when a current flows through it

★ Alternatively a current will flow through a circuit containing an inductor when the magnetic field through it changes

★ This effect can be used to detect metallic objects that interact with a magnetic field

★ Non metallic substances such as liquids or some kinds of dirt do not interact with the magnetic field, so an inductive sensor drives a coil with an oscillator

★ Reluctance → It is the property of a magnetic current which opposes the flow of magnetic flux

→ It is given by $R = \frac{l}{\mu_0 \mu_r A}$

Total Reluctance,

$$R_{TOTAL} = R_{core} + R_{Air\ gap} + R_{armature}$$

$$R_{core} = \frac{\pi R}{\mu_0 \mu_c \pi r^2} = \frac{R}{\mu_0 \mu_c r^2} \rightarrow (1)$$

$$R_{air\ gap} = \frac{2d}{\mu_0 \pi r^2} \rightarrow (2)$$

$$R_{armature} = \frac{2R}{\mu_0 \mu_A 2rt} = \frac{R}{\mu_0 \mu_A rt} \rightarrow (3)$$

$$R_{TOTAL} = (1) + (2) + (3)$$

$$R_{TOTAL} = \frac{R}{\mu_0 \mu_c r^2} + \frac{2d}{\mu_0 \pi r^2} + \frac{R}{\mu_0 \mu_A rt}$$

I) LVDT → Linear Variable Differential Transformer :-

★ Modified version of plunger type sensor

★ Arranged two sets of coil 1) Primary 2) Secondary (S1, S2)

★ The Coupling b/w primary and secondary varies by core plunger moving assembly.

★ An alternating voltage Supply V_i and frequency f is impressed ~~at the~~ across the primary coil and depending on the position of the core with respect to Py and two Secondaries an output voltage V_o is obtained

$$V_{os} = -\frac{n d\phi}{dt}$$

$$= -M \frac{di_p}{dt} \rightarrow (1)$$

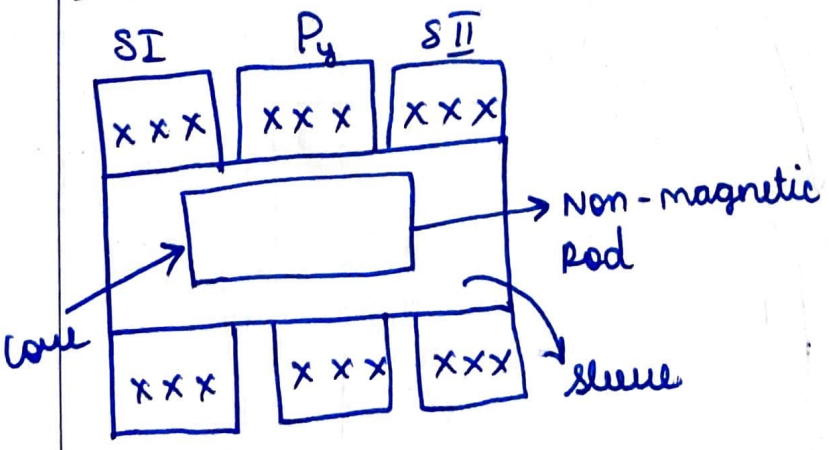
n → no. of turns in Sy coil

ϕ → Magnetic flux (primary & secondary)

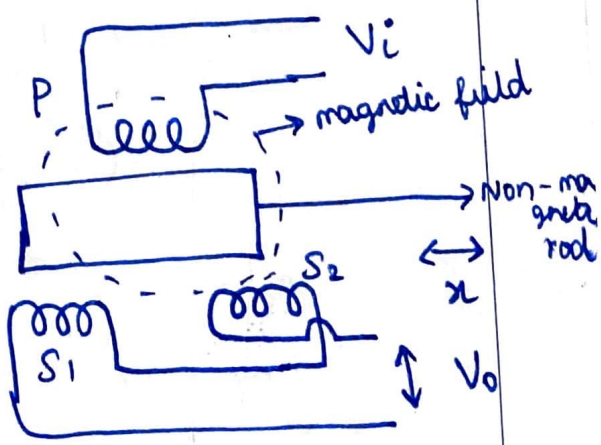
M → Mutual induction b/w Py & Sy

i_p → Primary input current

Scheme of an LVDT



equivalent Model



For the two coils diffuentially connected,

$$V_o = V_{os1} - V_{os2} = (M_1 - M_2)\frac{di_p}{dt} \rightarrow (2)$$

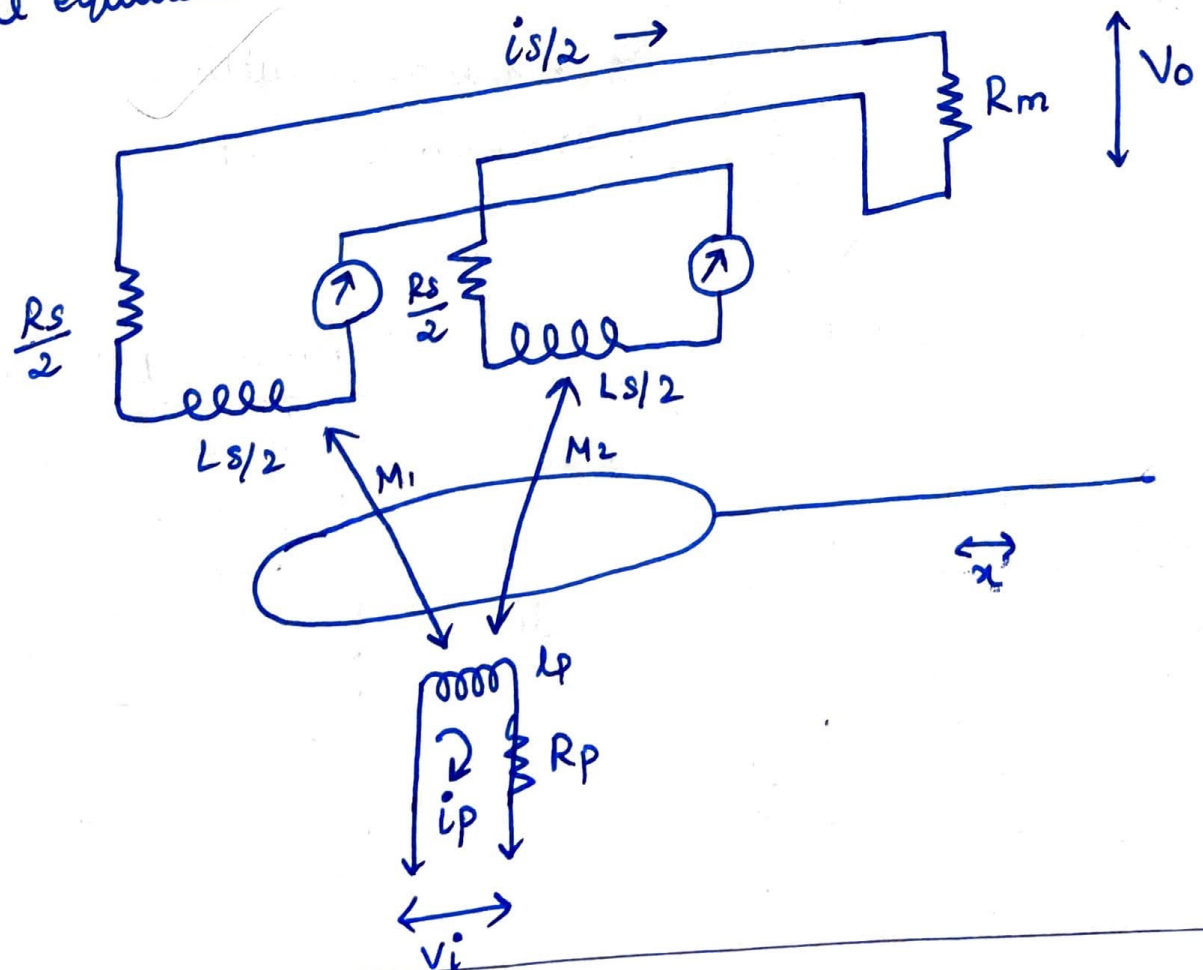
Both M_1 & M_2 are functions of x

$$M_1 - M_2 = M(x)$$

$$\Rightarrow M(x) = kx, \text{ so that}$$

$$x = \frac{V_o}{K\left(\frac{di_p}{dt}\right)} \rightarrow (3)$$

$\therefore$ The equivalent circuit of LVDT is,



solving for magnitude ratio per unit displacement

$\left|\frac{V_o}{V_i}\right|_x$, $f = \frac{\omega}{2\pi}$, if the meter load is R_m,

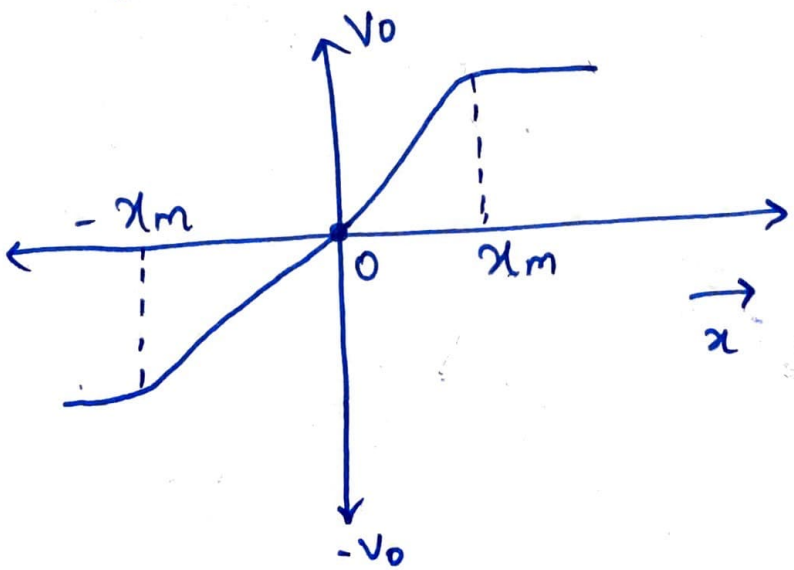
we get

$$\left|\frac{V_o}{V_i}\right| \cdot \frac{1}{x} = \frac{K\omega R_m / \{(R_s+R_m)R_p\}}{\sqrt{\left[\{1-\omega^2(\tau_m^2+\tau_p\tau_s)\}^2+\omega^2(\tau_p+\tau_s)^2\right]}}$$

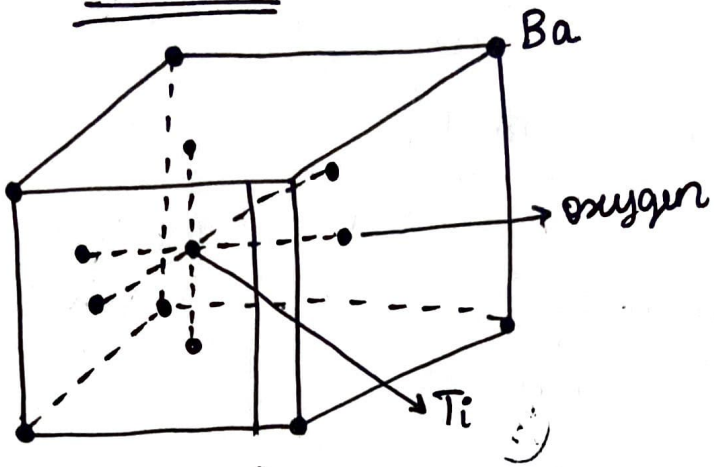
$$\phi = 90^\circ - \tan^{-1}\frac{\omega(\tau_p+\tau_s)}{1-\omega^2(\tau_m^2+\tau_p\tau_s)}$$

where $\tau_m = \frac{M_1-M_2}{\sqrt{(R_s+R_m)R_p}}$, $\tau_p = \frac{L_p}{R_p}$, $\tau_s = \frac{L_s}{R_s+R_m}$

The phase rectified secondary o/p voltage V_o with x is shown,



4) PIEZOELECTRIC ELEMENTS :-



$BaTiO_3$ modul

★ Materials are divided into 2 groups :

1) occur Naturally as Quarty, Rochelle salt - $NaKC_4H_4O_6$

2) those produced synthetically such as,

i) Lithium Sulphate (LS)

ii) Ammonium Dihydrogen Phosphate (ADP)

iii) Barium Titanate ($BaTiO_3$)

★ $BaTiO_3$ is actually a ferroelectric ceramic and requires to be polarized before use.

★ Besides these there are certain polymer films which also exhibit the piezoelectric property

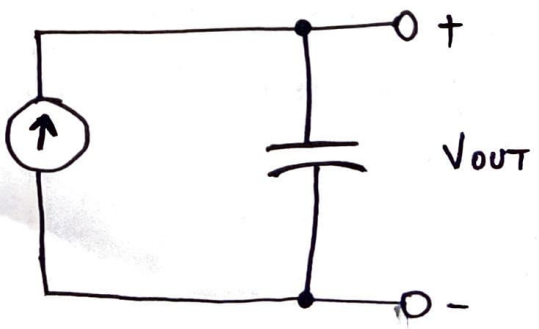
★ The material properties that are relevant to piezoelectric sensors are,

1) dielectric constant
2) d - coefficients
3) Resistivity
4) Young's modulus
5) Humidity Range
6) Temperature Range
7) Density

Applications :-

1) Pressure sensors
2) dot matrix printers & inkjet printers
3) Sonar Equipment
4) Piezo Speak
5) humidifiers
6) ultrasonic cleaning

$$I = \frac{dQ}{dt}$$



II) Pyroelectric thermal Sensor :-

★ The PET sensor is comparatively a new entrant in the area of thermal / temperature detection.

★ It comprises of type of ferroelectric material.

★ FE materials are non centrosymmetric and their ferroelectricity is attributed to the spontaneous electric polarization on a polar axis

★ The direction of the polarization can be changed by the application of electric field.

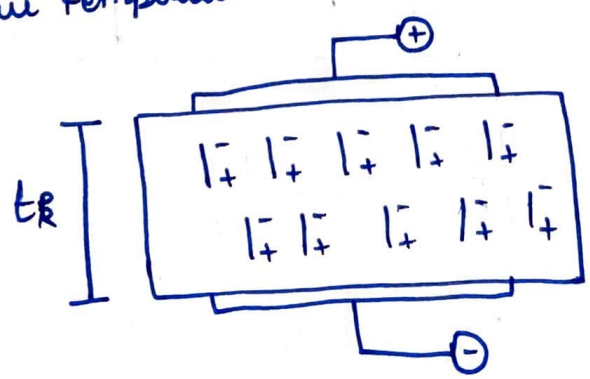
★ Also, there occurs a remanent polarization because of permanent electric dipole in the primitive unit cell of the crystal.

★ If the permanent dipoles in the material exhibit electric polarization with temperature, the characteristic property is called pyroelectricity.

★ Materials of this category are mainly ceramics.

★ If the temperature is now raised above a certain value, often called the Curie temperature or 'critical temperature'.

$P = \sigma E$ → (1)



★ The Electrical dipole are in ~~direct~~ random orientation in the material and the net electrical output is

$P = \sigma E$

$m = q l$

$l_t = l \cos\theta$

$m = q l \cos\theta$

$M = P_v A t_k$

$m = q l$

$l_t = l \cos\theta$

$m = q l \cos\theta$

$M = P_v A t_k$

$$m = q l$$

$$l_t = l \cos\theta$$

$$m = q l \cos\theta$$

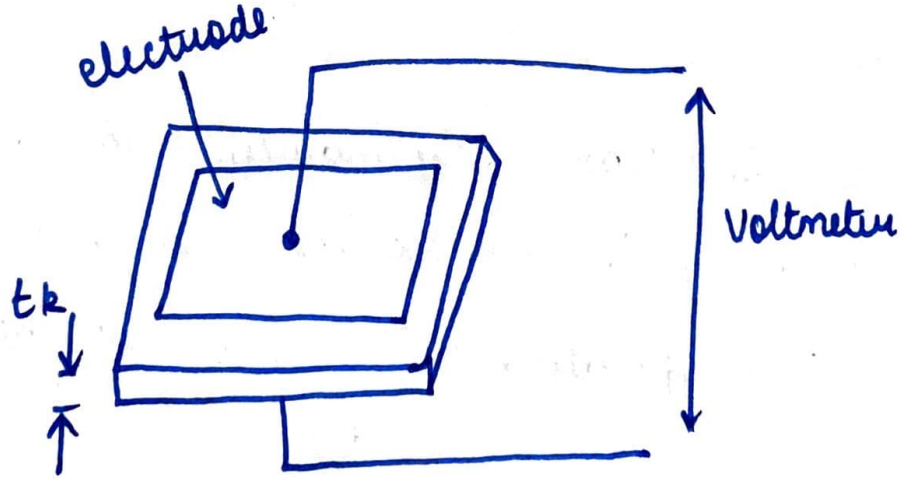
$$M = P_v A t_k$$

The charge, $Q = P_v A$

we know that dipole Moment $M = Q t_k$

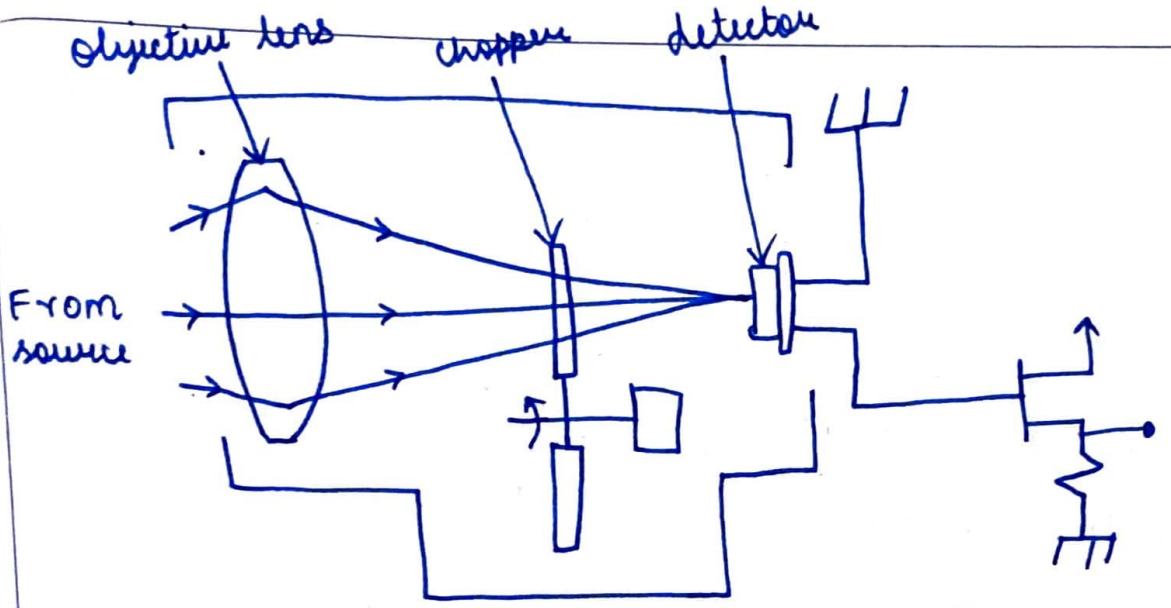
$$\frac{dQ}{dT} = \left(\frac{dP_v}{dT}\right) A = \phi A$$

$$\frac{dV}{dT} = \frac{1}{C} \cdot \frac{dQ}{dT} = \frac{\phi A}{C}$$



$$\frac{dV}{dt} = \frac{\phi A}{C} \frac{dT}{dt}$$

$$i = \phi A \frac{dT}{dt}$$



pyroelectric pyrometer arrangement

* The material is classified in terms of its figure of merit F,

$$F = \frac{\phi}{C_v P \varepsilon}$$

$$F_v = \frac{\phi}{P C_v \sqrt{\varepsilon} \tan\sqrt{\delta}}$$

where δ is the dielectric loss of the material. Such materials are widely used for photoradiation detection in IR region

Synchros

* transforms the angular position of the shaft into an electrical signal

* **Synchros System Types** :-

1) Control Type synchro
2) Torque transmission Type Synchro

1) CTS

* This type of synchros has small output torque. and hence they are used for running the very light load like pointer.
* The CTS is used for driving the large loads

2) TTTS

* The control synchros is used for error detection in positional control systems.
* This System consist of two units. They are,

1. Synchro Transducer
2. Synchro receiver