Unit -4

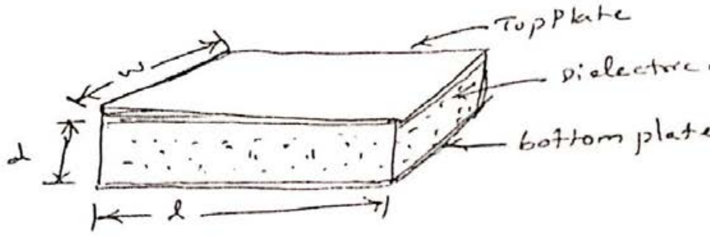
CAPACITIVE TRANSDUCERS

The principle of operation of capacitive transducer is based upon the equation for capacitance of a parallel plate capacitor.

$$C = \frac{\varepsilon A}{d}$$

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

Where
- $C \rightarrow$ Capacitance
- $\varepsilon \rightarrow$ Permitivity of medium F/m
- $\varepsilon_0 \rightarrow$ Permitivity of free Space F/m
- $\varepsilon_r \rightarrow$ Permitivity or relative permitivity
- $A \rightarrow$ overlapping area of plates ; m^2
- $d \rightarrow$ distance between two plates ; m



The capacitive transducer work on the principle of change of capacitance which may be caused by
- i) change in overlapping area A
- ii) change in the distance 'd' between the plates
- iii) change in dielectric constant.

These changes are caused by physical variables like displacement, force and pressure in most of the cases.

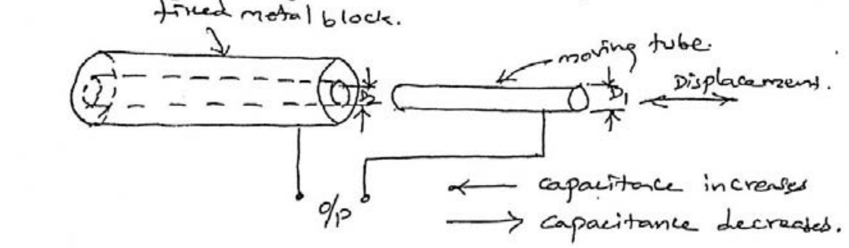
The capacitive transducers are commonly used for measurement of linear displacement

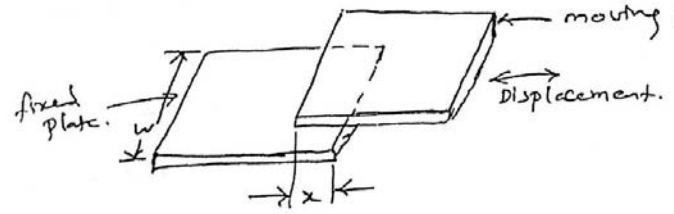
Change in Area of plates

we know capacitance $C = \frac{\varepsilon A}{d}$.

From this equation, the capacitance C is directly proportional to the area A of the plates. Therefore if there is change in area, the capacitance changes linearly.

This type of transducers are useful for measurement of moderate to large displacements from 1mm to several cm.





For a parallel plate capacitor,

$$C = \frac{\varepsilon A}{d} = \frac{\varepsilon x w}{d} \text{ Farad.}$$

where x = length of overlapping part of plates ; m
w = width of overlapping part of plates ; m

$$\text{Sensitivity} = \frac{\partial C}{\partial x} = \varepsilon \cdot \frac{w}{d} \ \text{F/m}$$

The Sensitivity is constant and therefore there is linear relationship between capacitance and displacement.

This capacitive transducer measure linear displacement from 1mm to 10mm. The accuracy is 0.005 %

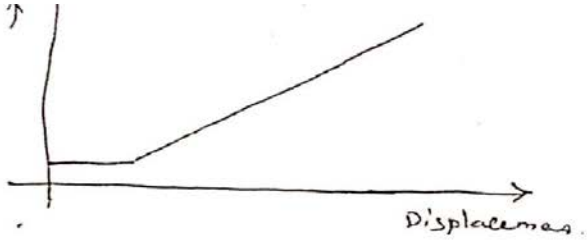
For a cylindrical capacitor

$$C = \frac{2\pi\varepsilon x}{\log_e (D_2/D_1)} \text{ Farad.}$$

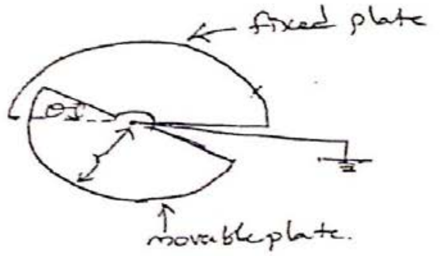
where x → length of overlapping part of cylinders ; m
D_2 → inner diameter of outer cylinder ; m
D_1 → outer diameter of inner cylinder ; m

$$\text{Sensitivity } S = \frac{\partial C}{\partial x} = \frac{2\pi\varepsilon}{\log_e (D_2/D_1)} \ \text{F/m.}$$

∴ linear relationship since sensitivity is constant.



The change in capacitance with change in area is used to measure angular displacement also.



Here one plate is fixed and other is movable. The angular displacement to be measured is applied to movable plate. The angular displacement changes the effective area between the plates and thus changes the capacitance. The capacitance is maximum when the two plates completely overlap. i.e. $\theta = 180°$

$$C_{max} = \frac{\varepsilon A}{d} = \frac{\varepsilon \pi r^2}{2d}$$

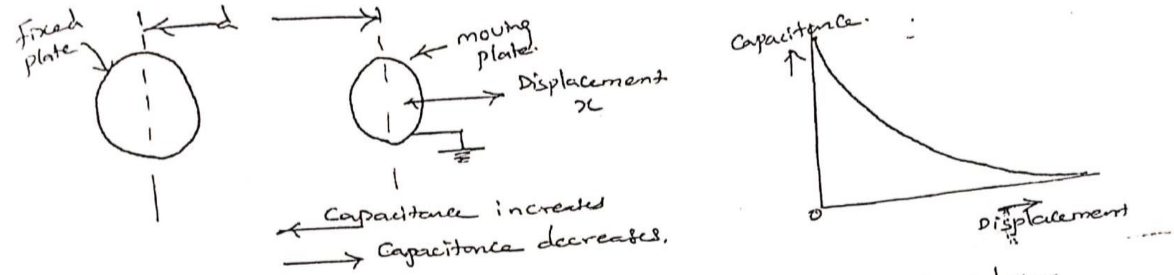
Capacitance at angle θ is $C = \frac{\varepsilon \theta r^2}{2d}$

$\theta \rightarrow$ angular displacement.

Sensitivity $S = \frac{\partial C}{\partial \theta} = \frac{\varepsilon r^2}{2d}$

Since S is constant, linear relationship is obtained.

change in distance between plates



The figure shows the basic form of capacitive transducer in which the change of capacitance is due to change in distance between the two plates. In this type one is a fixed plate and the displacement to be measured is applied to the other plate which is movable.

... proportional to the distance

which is movable.

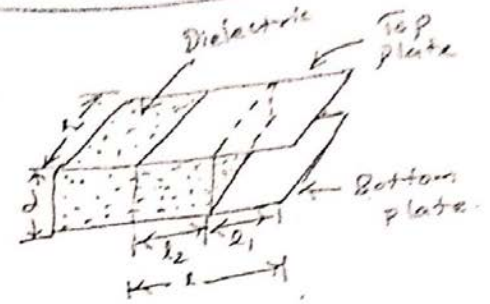
The capacitance c is inversely proportional to the distance 'd' between the plates. Therefore the response is not linear. Thus this transducer is useful only for measurement of extremely small displacements.

$$C = \frac{\varepsilon A}{x}$$

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

ii) Change in dielectric constant (Displacement measurement)

The figure shows a capacitive transducer for measurement of linear displacement working on the principle of change in dielectric constant. It has dielectric of relative permitivity ε_r



$$\text{Initial capacitance } C = \varepsilon_0 \frac{W l_1}{d} + \varepsilon_0 \varepsilon_r \frac{W l_2}{d}$$

$$= \varepsilon_0 \frac{W}{d}\left[l_1 + \varepsilon_r l_2\right]$$

If the dielectric moves to the right side by a distance x, then the capacitance changes from c to Δc.

$$c + \Delta c = \varepsilon_0 \frac{W}{d}(l_1 - x) + \varepsilon_0 \varepsilon_r \frac{W}{d}(l_2 + x)$$

$$= \varepsilon_0 \frac{W}{d}\left[l_1 - x + \varepsilon_r(l_2 + x)\right]$$

$$= \varepsilon_0 \frac{W}{d}\left[l_1 + \varepsilon_r l_2\right] + \varepsilon_0 \frac{W x}{d}\left[\varepsilon_r - 1\right]$$

$$= c + \varepsilon_0 \frac{W x}{d}(\varepsilon_r - 1)$$

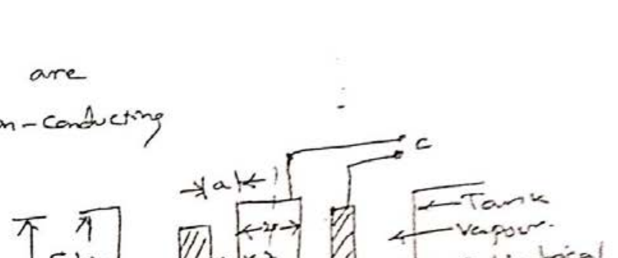
$$\therefore \Delta c = \varepsilon_0 \frac{W x}{d}(\varepsilon_r - 1)$$

this change in capacitance is proportional to displacement

b) Liquid level measurement

Capacitive transducers are used to measure the level of non-conducting liquids.

The electrodes are two concentric cylinders and the non-conducting liquid acts as the dielectric. At the lower end of the outer cylinder there are holes which allow passage of liquid.



$$C = 2\pi\varepsilon_0 \frac{\varepsilon_1 h_1 + \varepsilon_2 h_2}{\log_e (r_2/r_1)}$$

Where,

h_1 = height of liquid ; m

h_2 = height of cylinder above liquid; m

ε_1 = relative permittivity of liquid.

ε_2 = relative permitivity of vapour above liquid.

r_2 = inside radius of outer cylinder ; m

r_1 = outside radius of inner cylinder ; m

ε_0 = Permitivity of free space ; F/m

$h >> r_2$

$r_2 >> r_2 - r_1 >> a$

$r_2 = r + a$

$r_1 \simeq r$

$$\therefore C = 2\pi \varepsilon_0 \frac{\varepsilon_1 h_1 + \varepsilon_2 h_2}{\log_e(1 + a/r)}$$

Advantages of Capacitive transducers

1) extremely small force is required to operate.
2) highly Sensitive
3) Good frequency response.
4) high input impedance
5) Resolution in the order of 2.5×10^{-3} mm
6) Small power to operate.

Disadvantages

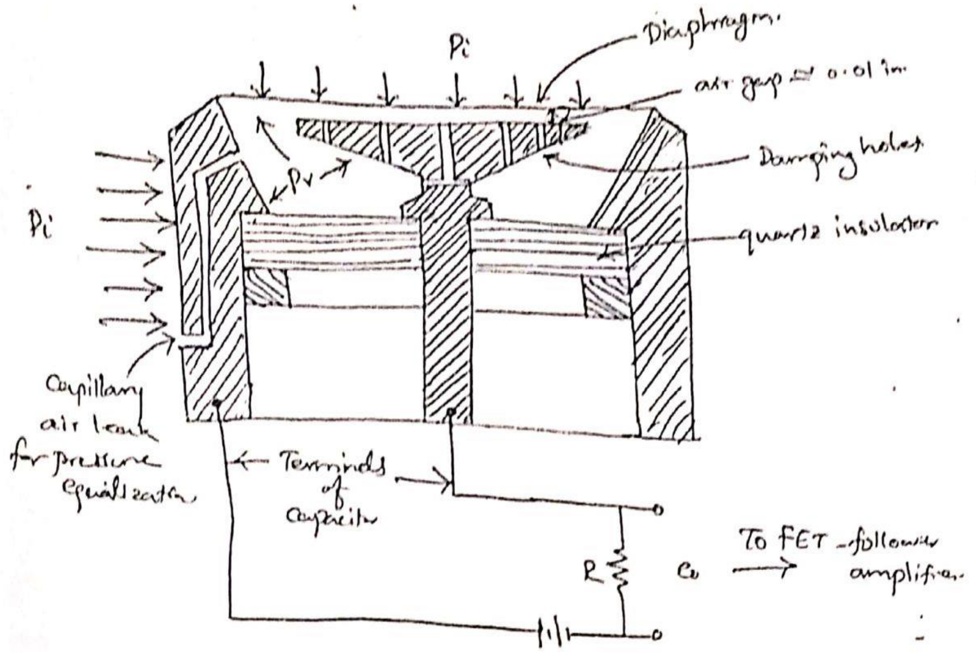
1) metallic parts must be insulated from each other
2) non-linear behaviour due to edge effect. Guard rings must be used to eliminate this effect.
3) high output impedance which lead to loading effect. Output impedance depends on frequency of the signal. For capacitances lying between 10-50pF the frequency used are such that they give an output impedance in the range of 1kΩ to 10MΩ.
4) Cable connecting the transducer to the measuring point is also a source of error.

Microphone

A transducer that converts sound in to electrical signal

Capacitor microphone

Of several types, capacitor microphone is considered capable of the highest performance.



In this microphone diaphragm is the sensing element. It is deflected by the sound pressure and acts as a moving plate of a capacitor. The diaphragm is a very thin membrane which is stretched by a suitable clamping arrangement. Its thickness ranges from about 0.0001 to 0.002 in. The other plate of the capacitor is stationary and may contain properly designed damping holes. Motion of diaphragm causes air flow through these holes. The damping effect is utilized to control the resonant peak of the diaphragm response.

A capillary leak is provided to give equalization of steady pressure on both sides of the diaphragm to prevent diaphragm bursting

The Variable Capacitor is connected into a simple series circuit with a high resistance R and polarized with a dc voltage E_b of about 200V. This voltage acts as circuit excitation and determines the neutral diaphragm position because of the electrostatic attraction force between the capacitor plates. For a constant diaphragm deflection, no current flows through R and no output voltage e_o exists, thus there is no response to static pressure differences across the diaphragm. For dynamic pressure differences, a current will flow through R and an output voltage exists. The voltage e_o is applied to the input of a FET - follower amplifier. The purpose of the amplifier is to prevent loading of the micro phone by its high input impedance. The output impedance of the amplifier is low and its output signal may be coupled into long cables and low - impedance loads without loss of signal magnitude.

Piezo - electric transducers

A piezo - electric material is one in which an electric potential is produced across certain surfaces of a crystal if the dimensions of the crystal are changed by the application of a mechanical force. This potential is produced by the displacement of charges.

The effect is reversible, if a varying potential is applied to the proper axis of the crystal, it will change the dimensions of the crystal thereby deforming it. This effect is known as piezo - electric effect. Elements exhibiting piezo - electric qualities are called as electro - resistive elements.

Common Piezo - electric materials include (Rochelle salts, ammonium dihydrogen phosphate, lithium sulphate, dipottasium - tartarate, Potassium dihydrogen phosphate, quartz & Ceramics.) The Ceramic materials are poly crystalline in nature.

The materials that exhibit a significant and useful piezo electric effect are divided into two categories:

i) Natural group

ii) Synthetic group.

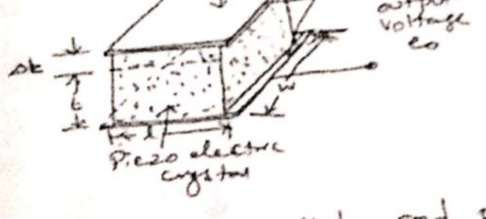
Quartz and Rochelle salt belongs to natural group while materials like lithium sulphate, ethylene diamine tartarate belong to the synthetic group.

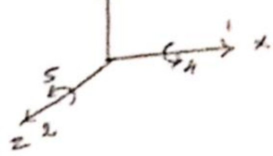
The piezo-electric effect can be made to respond to mechanical deformations of the material in many different modes.

The modes can be: thickness expansion, transverse expansion, thickness shear and face shear. A piezo electric element used for converting mechanical motion to electrical signals may be thought as charge generator and a capacitor. Mechanical deformation generates a charge and this charge appears as a voltage across the electrodes.

The voltage is $E = Q/C$

The piezo electric effect is direction sensitive. A tensile force produces a voltage of one polarity while a compressive force produces a voltage of opposite polarity.





The magnitude and polarity of the induced surface charges are proportional to the magnitude and direction of the applied force F. The polarity of induced charge depends on the direction of applied force.

Charge $Q = d \times F$ coulomb

where d = charge sensitivity of the crystal ; C/N

F = applied force ; N

The force F causes a change in thickness of the crystal

$$F = \frac{AE}{t} \Delta t \text{ newton.}$$

where

A = area of the crystal ; m^2

t = thickness of crystal ; m

E = Young's modulus ; N/m^2

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{F}{A} \cdot \frac{1}{(\Delta t/t)}$$

$$= \frac{Ft}{A\Delta t} \; N/m^2$$

Area $A = wl$

$w \rightarrow$ width of the crystal ; m

$l \rightarrow$ length of the crystal ; m

now charge $Q = d \cdot AE \frac{\Delta t}{t}$

The charge at the electrodes gives rise to an o/p voltage

$$\therefore E_0 = Q/C_p$$

$C_p \rightarrow$ capacitance between electrodes ; F

$$C_p = \frac{\varepsilon_r \varepsilon_0 A}{t}$$

$$E_0 = \frac{Q}{C_p} = \frac{dF}{\varepsilon_r \varepsilon_0 A/t} = \frac{dt}{\varepsilon_r \varepsilon_0} \cdot \frac{F}{A}$$

$\frac{F}{A} = p \rightarrow$ pressure or stress.

$$\therefore E_0 = \frac{d}{\varepsilon_r \varepsilon_0} t \cdot P$$

$$\boxed{E_0 = g t P}$$

$g = \frac{d}{\varepsilon_r \varepsilon_0} \Rightarrow$ voltage sensitivity of the crystal.

$$g = \frac{E_0}{tP} = \frac{E_0/t}{P}$$

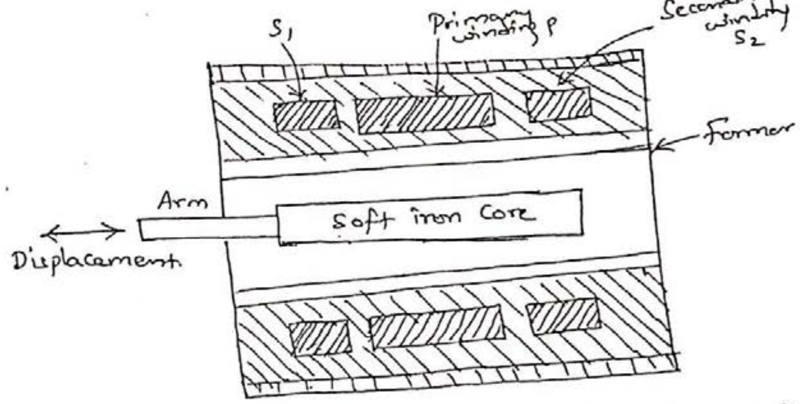
$\frac{E_0}{t} \Rightarrow$ electric field strength $= \mathcal{E}$

$$\boxed{g = \frac{\mathcal{E}}{P}}$$

$\therefore$ Crystal voltage sensitivity is the ratio of the electric field intensity to pressure.

Linear Variable Differential Transformer (LVDT)

LVDT is an inductive transducer used to translate linear motion into electrical signal.



The transformer consist of a single primary winding P and two secondary windings S_1 and S_2. The number of ~~windings~~ turns in 2 secondary windings are equal and are identically placed on either side of the primary. Primary winding is connected to alternating current source. A movable soft iron is placed inside the former. The displacement to be measured is connected to the arm fixed with movable soft iron core. The core is made of high permeability nickel iron which is hydrogen annealed. This gives low harm.. low null voltage and a high sensitivity. The assembly is, p' in a stainless steel housing and the end lids provide electr and electromagnetic shielding.

Since the primary winding is excited with an a.c. source, it induce a.c. voltage in 2 secondary windings.

The output voltage of S_1 is Es_1 & S_2 is Es_2. To convert these two voltages into a single voltage S_1 and S_2 are connected in series opposition. Thus the output voltage is the ~~difference~~ difference between Es_1 & Es_2

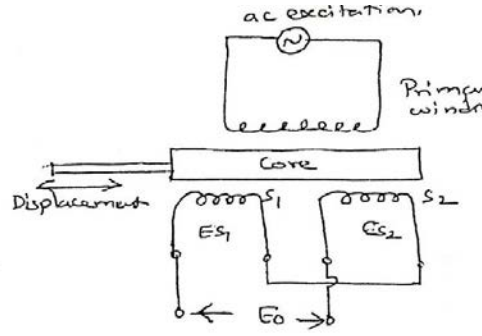
Differential output voltage $E_0 = Es_1 - Es_2$

When the core is at null position (no displacement), flux linking with S_1 & S_2 are equal and it induce emf in it.

At null position $Es_1 = Es_2$

$\therefore E_0 = 0$

i.e. output voltage at null position is zero.



If the core moves from null position in the left side, more flux linking with S_1 and so more emf induced in S_1 than S_2. Therefore E_{S_1} is greater than E_{S_2}

The magnitude of output voltage is $E_0 = E_{S_1} - E_{S_2}$,

the output Voltage at this condition is in phase with Primary voltage.

If core moved in right side from null position, More flux linking with S_2 than S_1. So more voltage at S_2.

now $E_0 = E_{S_1} - E_{S_2}$

in this case output voltage is 180° out of phase with primary voltage.

The amount of voltage change in either secondary winding is proportional to the amount of movement of the core. It indicates the amount of linear motion.

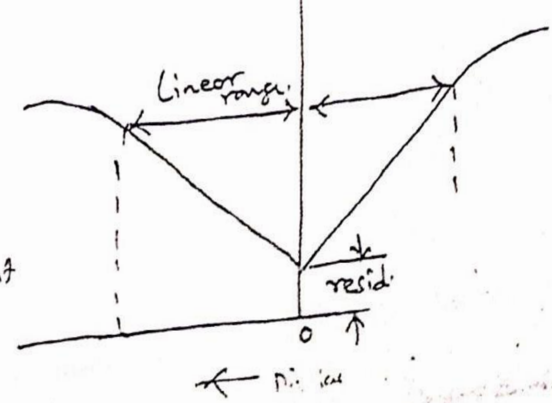
The direction of the motion is ~~noted by~~ determined by noting which output voltage is increasing or decreasing.

Any physical displacement of the core causes the voltage of one secondary winding to increase while simultaneously reducing the voltage in another secondary winding. The difference of the two voltages appears across the output terminals of the transducer and gives a measure of the physical position of the core and hence the displacement

As the core is moved in one direction from the null position, the differential voltage will increase while maintaining an in-phase relationship with the input. If core moved in another direction from null position, the differential voltage will also increase, but will be 180° out of phase with the input. By comparing the magnitude and phase of the output voltage, the ~~amount and~~ amount of displacement direction of the movement of the core and hence of displacement can be determined.

Ideally the output voltage at the null position should be equal to zero. But in practice there exist some small voltage at null position. This is due to presence of harmonics in the input supply voltage and also due to harmonics produced in output voltage on account of use of iron core. There may be either an incomplete magnetic or electrical unbalance or both which results in a finite output voltage at null position. This finite residual voltage is generally less than 1% of the maximum output voltage.

The variation of output voltage with input displacement is linear for a limited range. Beyond this range of displacement the curve starts to deviate from a straight line.



Advantages of LVDT

1) High range. Displacement from 1.25mm to 250mm can be measured.

2) No physical contact between movable iron core and coil structure. So there is no friction. Therefore LVDT can respond to even minute motion of the core and produce an output.

3) Immunity from external effects. The separation between LVDT core and coil permits the isolation of media such as pressurized, corrosive or caustic fluids from the coil assembly by a non-magnetic barrier interposed between the core and coil.

4) High output — no need for amplification

5) High sensitivity

6) Ruggedness — tolerate high degree of shock & vibrations.

7) Low hysteresis

8) Low power consumption – less than 1W.

Disadvantages

1. Large displacements required for appreciable differential output

2. Sensitive to stray magnetic field, but shielding is possible.

3. the receiving instrument must be selected to operate on a

4. Dynamic response is limited by the mass of the core.

5. Sensitive to temperature changes.

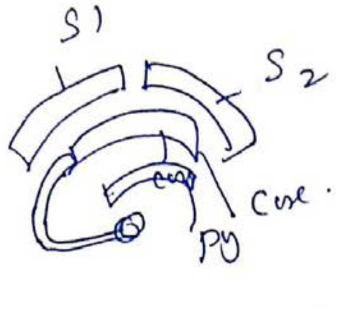
Uses

1. Displacements ranging from fraction of mm to a few cm can be measured.

2. Acting as a secondary transducer, force, weight, pressure can also be measured.

RVDT

RVDT –



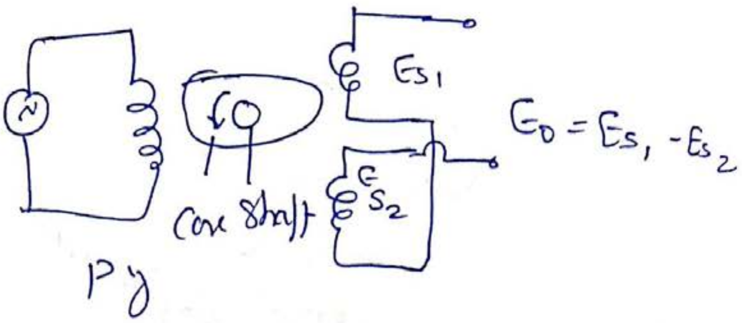
Rotary variable differential Transformer.

Rotating iron core.

(1) converts rotary or angular displacement into electrical voltage.

±60°

RVDT is not advisable to use if rotation is > ±60°



Core is rotated by means of shaft but the windings

Amount of angular displacement & its direction may be ascertained from the

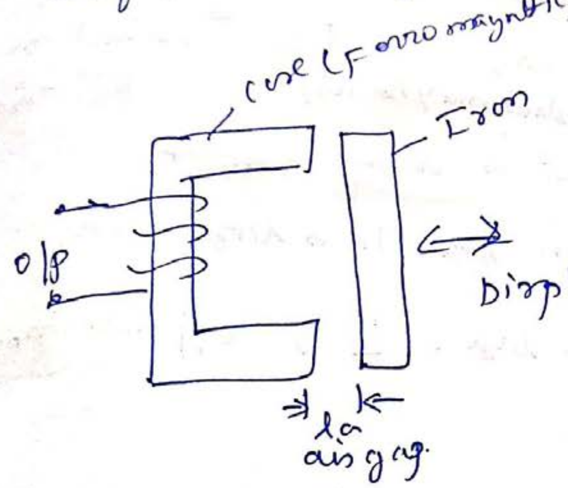
magnitude & phase of the o/p voltage to the transducer.

VARIABLE RELUCTANCE TRANSDUCER

$$L = \frac{\mu_0 \mu_r A N^2}{l} \text{ (Henry) } H \qquad L = \frac{N^2}{\text{Reluctance}}$$

Self inductance of the coil

$$\text{Reluctance} = \frac{l}{\mu_0 \mu_r A}$$



Change in inductance may be calibrated in terms of displacement

used for measurement of pr,
force,
displacement

$$\text{Reluctance of air gap} = \frac{l_a}{\mu_0 A}$$

$$L \propto \frac{1}{l_a}$$ — l_a – air gap length.

✓ The self inductance of the coil is given by

$$L = \frac{N^2}{2R_a + R_i}$$

R_i → Reluctance of iron path

R_a → Reluctance of air gap

R_i is negligible as compared to reluctance of air gap

$$L \simeq \frac{N^2}{2R_a}$$

Reluctance of airgap $R_a = \frac{l_a}{\mu_0 A_a}$

l_a → length of air gap

A_a → Area of cross section of flux through air

$R_a \propto l_a$ as μ_0 & A_a are constant

Hence $L \propto \frac{1}{l_a}$

Self Inductance of the coil is inversely proportional to the length of airgap.

when the target is near to the core, the length of air gap is small & so the L is large, when the target is away from the core, the length of air gap is large & hence L is small

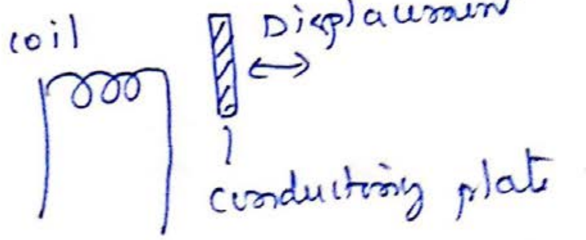
so self Inductance is a function of displacement.

L is a non-linear function of displacement.

Eddy current non contacting transducer

principle

If a conducting plate is placed near a coil carrying alternating current, eddy currents are produced in the conducting plate. The conducting plate acts as a short circuited secondary of a transformer. The eddy currents flowing in the plate produce a magnetic field of their own which acts against the magnetic field produced by the coil. This results in reduction of flux and thus the inductance of the coil is reduced. The nearer is the plate to the coil, the higher are the eddy currents and thus higher is the reduction in the inductance of the coil. Thus inductance of the coil alters with variation of distance between the plate and the coil.



UNIT -5

OPTICAL FIBERS

Optical fibers are thin, flexible threads of transparent glass or plastic that can carry visible light. Optical fibers consists of two concentric layers called the core and the cladding as shown in Fig. 1. The core, cladding along with the surrounding protective jacket constitute the fiber cable.

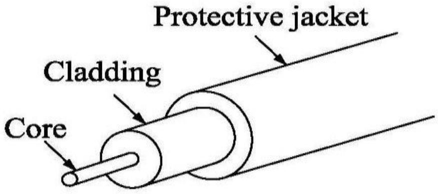


Fig. 1 Fiber optic cable

Principle of optical fibers

If a beam of light crosses the boundary between two materials, of refractive indices n_1 and n_2 then it will be refracted as shown in Fig. 2.

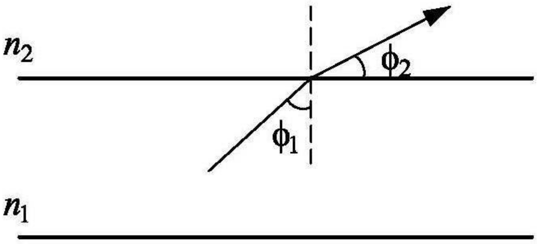


Fig.2 Illustration of refraction

As the angle of incidence ϕ_1 is increased, a point is reached when the beam is totally internally reflected. For this to occur inequalities Equation 1 and 2 must both be true.

$$n_2 < n_1 \qquad (1)$$

$$\phi_1 > \cos^{-1}\left(\frac{n_2}{n_1}\right) \qquad (2)$$

The angle at which total internal reflection first starts is called the critical angle and is given by

$$\phi_c = \cos^{-1}\left(\frac{n_2}{n_1}\right) \qquad (3)$$

The principle of total internal reflection is used to transmit light along optical fibers as in Fig 3.

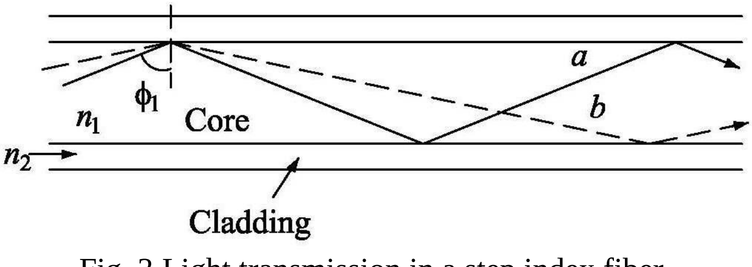


Fig. 3 Light transmission in a step index fiber

Type of Configurations

There are basically two type of optical fibre sensor configurations as shown in Fig. 4. These are

(a) Extrinsic sensors (or incoherent sensors)
(b) Intrinsic sensors (or coherent sensors)

The emitter, which may be a light emitting diode or a laser source, emits the light rays through the fiber, which gent modulated due to the outer signal, which is to be measured. The output fiber is connected to the detector, which converts the optical energy into electrical energy. These detections work on the principle of creation of an electron-hole pair in semiconductors or the release of electrons from the cathode of the photomultiplier tube. In the case of the extrinsic sensor, as in Fig. 4 (a) in the intensity modulation of light takes place outside the fibre, while in the case of Fig 4 (b) viz. Intrinsic sensor, it takes place within the fibre. Examples of the two types of sensors are given in Fig. 5

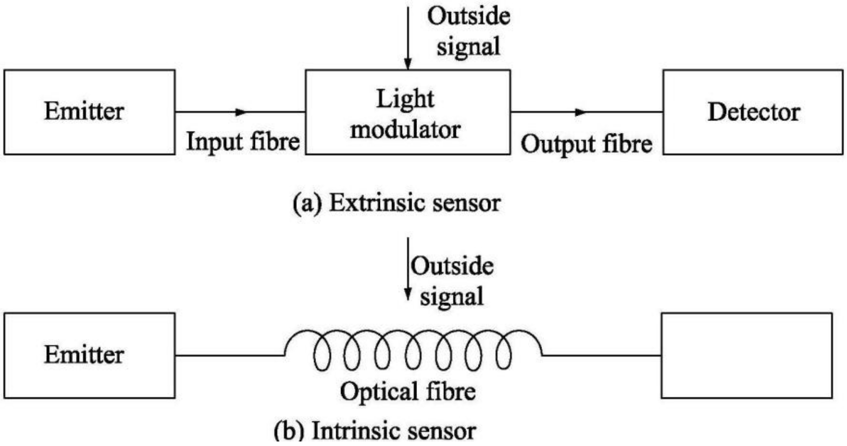


Fig. 4 Types of Optical Fibre Sensor configurations

Fig. 5 (a) shows an extrinsic or external intensity modulator type of sensor in which the position of the reflector due to motion to be measured may change, thus changing the light intensity in the output fiber. This is detected by a detector.

In Fig. 5 (b) the fibre bending due to the pressure, which is the input variable, to be measured induces radiation losses, changing the intensity at the output. This happens within the fibre itself and hence the configuration is called as intrinsic type. This causes radiation of light even at small deformation and is also called micro-bend sensor. In this type of sensor configuration, apart from the intensity modulator, there may be phase or frequency modulation, which after detection may be used for several modulator, there may be phase or frequency modulation, which after detection may be used for several applications.

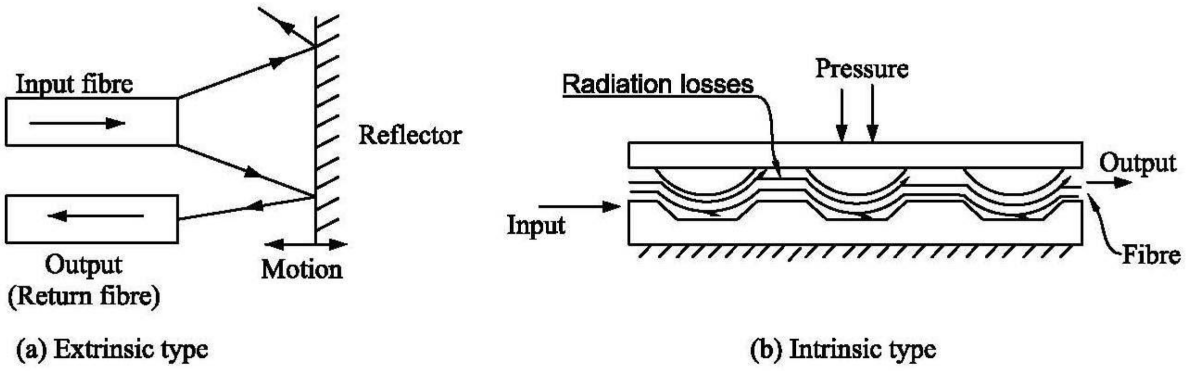


Fig. 5 Example of extrinsic and intrinsic type sensors

Applications

A number of applications for the measurement of various physical variables and described as follows: Fig. 6 shows an arrangement for the measurement of the pressure involving an extrinsic type of sensor in which the light form the input fibre is reflected from a diaphragm and picked up by the output fibres. The application of pressure deflects the diaphragm and the intensity of the reflected light depends on the diaphragm deflection.

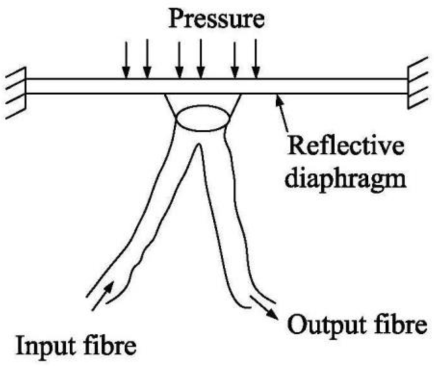


Fig. 6 A typical fibre optic pressure transducer

Fig 7 shows the configuration of a temperature sensor. It is seen that the phase of light gets changed due to the change in the length of the fibre as a result of application of longitudinal strain due to thermal expansion. The change in phase is converted to intensity variations using a Mach Zehnder interferometer as shown in the figure. 7 The intensities at the two detectors are seen to be proportional to $1 \pm \cos\delta$, when δ is the phase change due to the phase modulation. The value of δ for glass fibre is about 100 rad/°C/m of length and thus the device is highly sensitive. This type of device is of intrinsic or of coherent type.

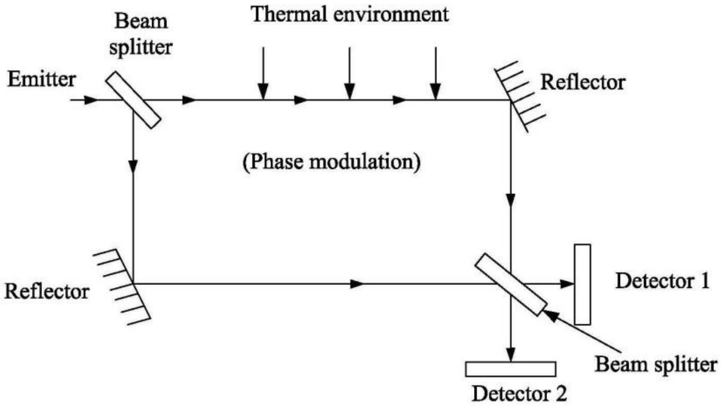


Fig. 7 A typical fibre optic temperature sensor

In the flow sensor as shown in Fig. 8 the frequency of light waves scattered from the particles in the moving fluid is Doppler shifted, the frequency shift being proportional to velocity. The input optical fibre carries light, which is focussed on the fluid flow. The output fibre carries the light scattered by the particles in the flowing fluid and particle velocity is found from the modulated frequency spectrum. This is an extrinsic or incoherent type of fibre optic sensor since the sensing takes place outside the fibre.

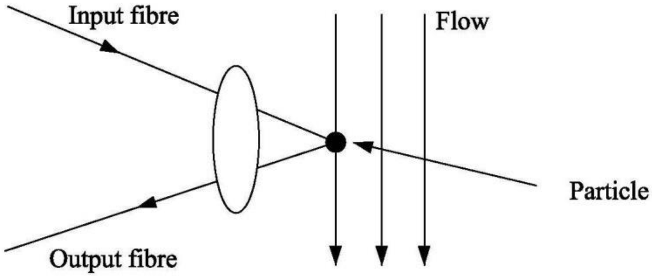
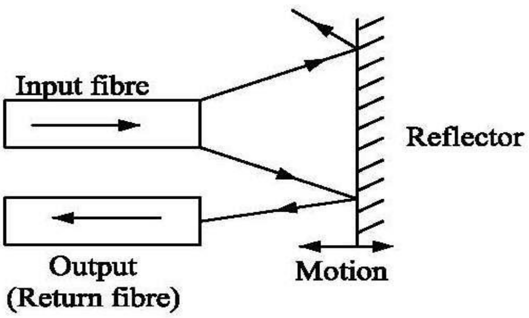


Fig. 8 A typical fibre optic flow sensor

Measurement of Displacement

Fig. 9 shows an extrinsic or external intensity modulator type of sensor in which the position of the reflector due to motion to be measured may change, thus changing the light intensity in the output fiber. This is detected by a detector.The light is reflected by a flat mirror surface on to a receiving fiber.The light intensity in the output fibre is a function of distance d to the surface.



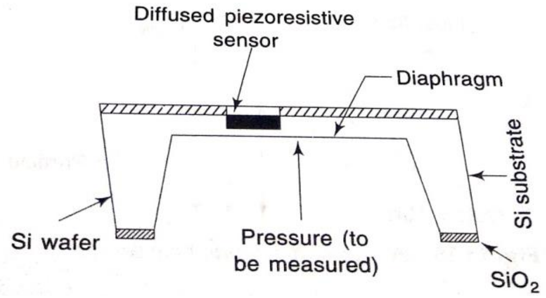
←--d-→

Fig.9 Measurement of displacement

Silicon micro sensor - Miniaturistation of sensor

Silicon is used as a base material for making micro sensor. Silicon is a good substrate for incorporating the associated signal conditioning circuitry. The sensor along with the signal conditioning electronic components are mounted on the same silicon substrate.

Usually a semi conductor(piezo resistive material) is diffused on the silicon substrate at the region of maximum strain. The resistance of the piezo resistive material changes with strain which with wheatstone bridge can given an output.



Diaphragm type siliconMicro pressure sensor

Smart sensors

The sensor having decision-making and communication logic added to the basic sensor, are called smart or intelligent sensors. Some of the other features included in such sensor are compensation for interfering inputs, linearization, self-test and calibration facility. There are usually microcomputers and other elements on the same chip whenever possible.

For data acquisition used the smart pressure sensor, the functional diagram is as shown in Fig. 10. If a piezo resistive sensor is used, as primary sensor for pressure, the main interfering input is temperature and so a secondary temperature sensor is used to compensate for the effect of temperature on resistance change. The memory of the microcontroller has calibration data stored in it. The microcontroller is essentially a microprocessor with input/output (I/O) facility.

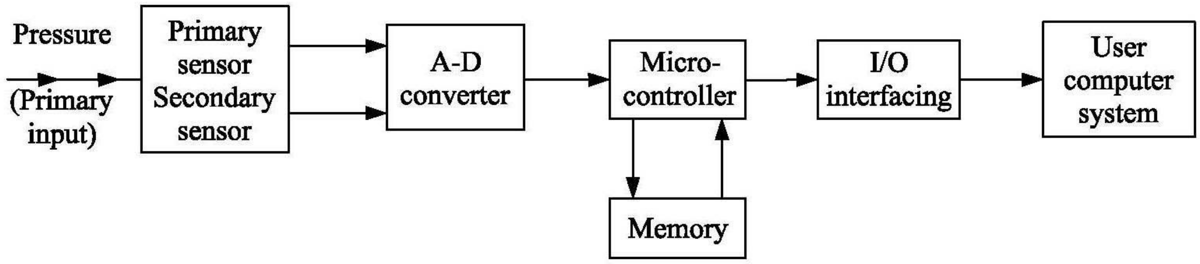


Fig. 10 Data acquisition system using smart pressure sensor

IC temperature sensor

LM 335 → provides an output of 10 mV/°K

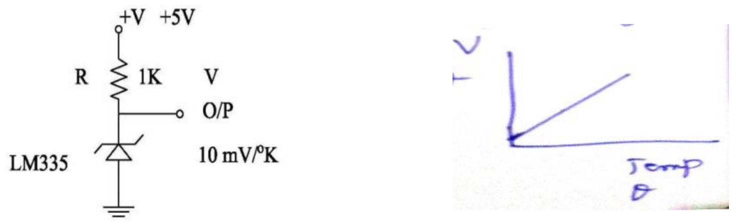


Fig 11. IC temperature sensor

LM335 sensor is a temperature sensitive zener diode (which with reverse biased in to its breakdown region gives an output of 10 mV°K). The breakdown voltage is directly proportional to absolute temperature. It can be used for temperature sensing in range of -40°C to 100°C.

Disadvantages of IC temperature sensor

1. Temperature limited to 150 deqree C
2. power supply required
3. slow
4. self heating

Advantages of IC temperature sesor

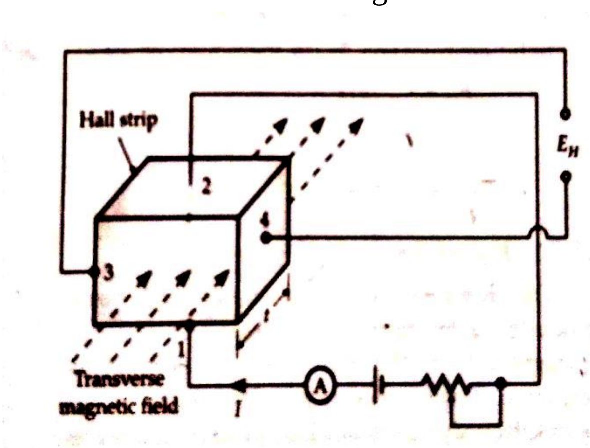
1. Most Linear
2. Highest output
3. Inexpensive

Hall effect transducer

Hall effect is production of voltage difference across an electrical conductor transverse (perpendicular) o the current in the conductor, when a magnetic field is applied in a direction perpendicular to the current. The magnitude of the developed voltage depends on the density of flux and this property of a conductor is called the Hall Effect

Hall effect element is mainly used for magnetic measurement and for sensing the current metal of semi conductor has the property of Hall effect.

Fig. 12 Hall effect



Output voltage

$$E_H = K_H\, IB/t$$

Where K_H Hall coefficient
t Thickness of strip in m
I Current in ampere
B flux density in Wb/m^2

Measurement of displacement using Hall Effect transducer

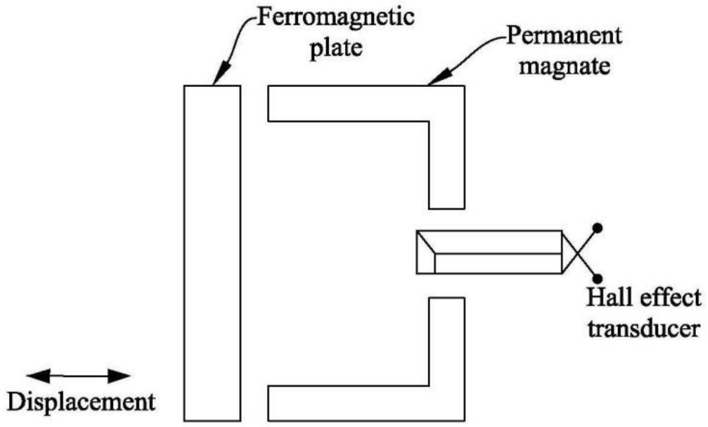


Fig. 13 Hall effect transducer

The Hall Effect transducer placed between the poles of the permanent magnet. The Magnetic field strength across the Hall Effect transducer changes by changing the position of Ferro magnetic plate

Applications of Hall effect transducer

1. Magnetic to electric transducer
2. Measurement of Displacement
3. Measurement of current
4. Measurement of power