EIPC
NEE-403
Unit-2
Capicitive & piezoelectric transducer

Capacitive Transducer

The capacitance of a parallel plate capacitor is given by

$$C = \frac{kA\varepsilon_0}{d}(Farads)$$

where

k	=	dielectric constant
A	=	the area of the plate, in m^2
ε_o	=	8.854×10^{-12} F/m
d	=	the plate placing in m

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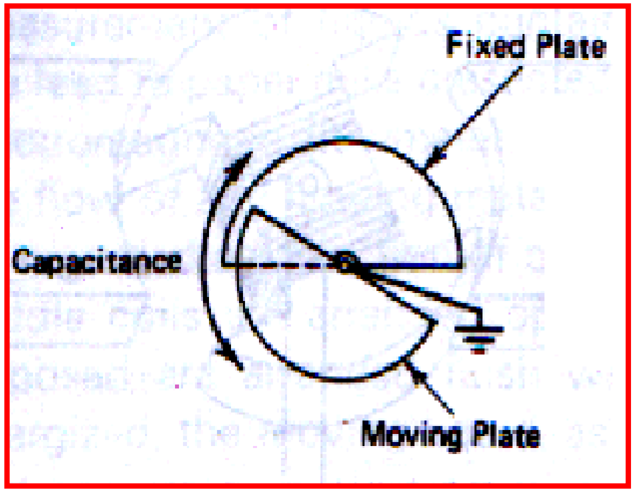
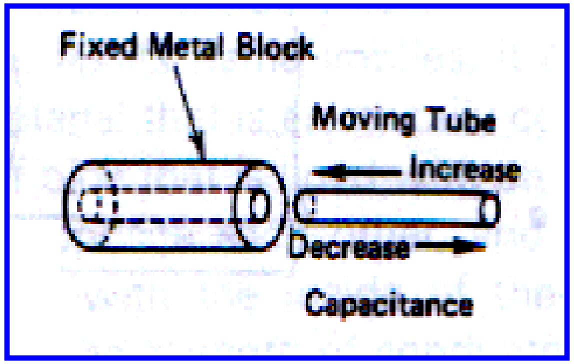
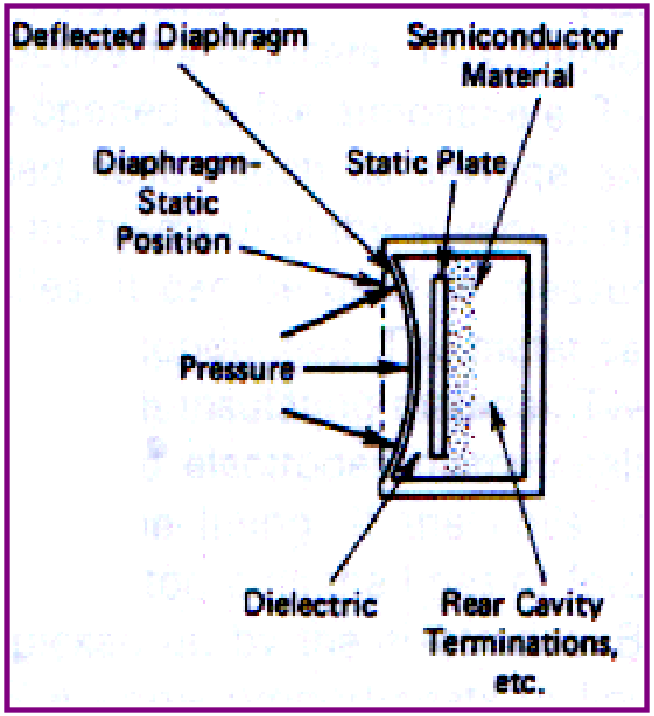
Forms of Capacitance Transducers



Rotary plate capacitor



Rectilinear Capacitance Transducer



Thin diaphragm

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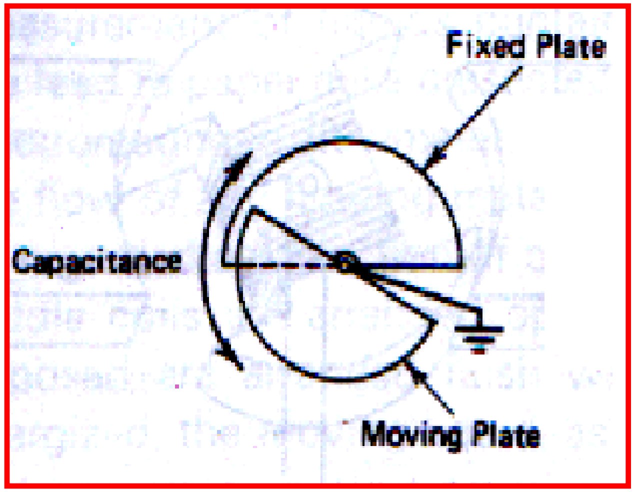

Rotary plate capacitor:

The capacitance of this unit proportional to the amount of the fixed plate that is covered, that shaded by moving plate. This type of transducer will give sign proportional to curvilinear displacement or angular velocity.

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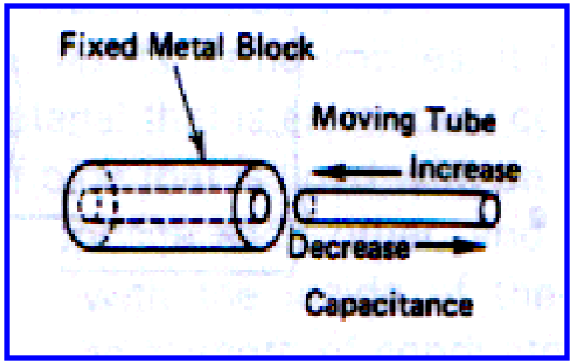
Rectilinear capacitance transducer:

It consists of a fixed cylinder and a moving cylinder. These pieces are configured so the moving piece fits inside the fixed piece but insulated from it.



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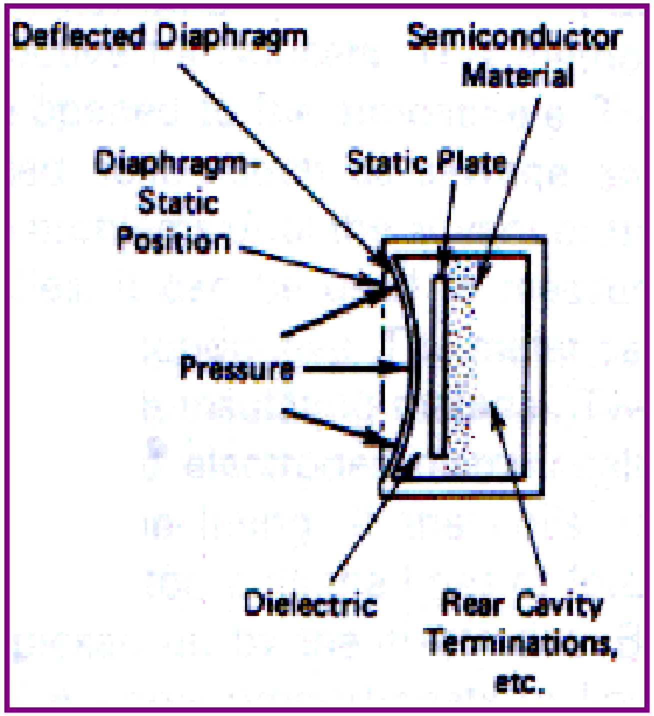
Thin diaphragm:

A transducer that varies the spacing between surfaces. The dielectric is either air or vacuum.

Often used as Capacitance microphones.



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Advantages:

1. Has excellent frequency response
2. Can measure both static and dynamic phenomena.

Disadvantages:

1. Sensitivity to temperature variations
2. the possibility of erratic or distortion signals owing to long lead length

Applications:

1. As frequency modulator in RF oscillator
2. In capacitance microphone
3. Use the capacitance transducer in an ac bridge circuit

Piezoelectric effect

- Discovered in 1880 by Jacques and Pierre Curie during studies into the effect of pressure on the generation of electrical charge by crystals (such as quartz).
- Piezoelectricity is defined as a change in electric polarization with a change in applied stress (direct piezoelectric effect).
- The converse piezoelectric effect is the change of strain or stress in a material due to an applied electric field.

Piezoelectric effect

- The linear relationship between stress X_{ik} applied to a piezoelectric material and resulting charge density D_i is known as the direct piezoelectric effect and may be written as

$$D_i = d_{ijk} X_{jk}$$

- where d_{ijk} (C N^{-1}) is a third-rank tensor of piezoelectric coefficients.

Piezoelectric effect

- Another interesting property of piezoelectric material is they change their dimensions (contract or expand) when an electric field is applied to them.
- The converse piezoelectric effect describes the strain that is developed in a piezoelectric material due to the applied electric field:

$$x_{ij} = d_{kij} E_k = d^t_{ijk} E_k$$

- where *t* denotes the transposed matrix.
- The units of the converse piezoelectric coefficient are (m V^{-1}).

Piezoelectric effect

- The piezoelectric coefficients, *d* for the direct and converse piezoelectric effects are thermodynamically identical, i.e.

  $d_{\mathrm{direct}} = d_{\mathrm{converse}}$.

- Note that the sign of the piezoelectric charge D_i and strain x_{ij} depends on the direction of the mechanical and electric fields, respectively.
- The piezoelectric coefficient *d* can be either positive or negative.

Piezoelectric effect

- It is common to call a piezoelectric coefficient measured in the direction of applied field the longitudinal coefficient, and that measured in the direction perpendicular to the field the transverse coefficient.
- Other piezoelectric coefficients are known as shear coefficients.
- Because the strain and stress are symmetrical tensors, the piezoelectric coefficient tensor is symmetrical with respect to the same indices,

$$d_{ijk} = d_{ikj} .$$

Piezoelectricity

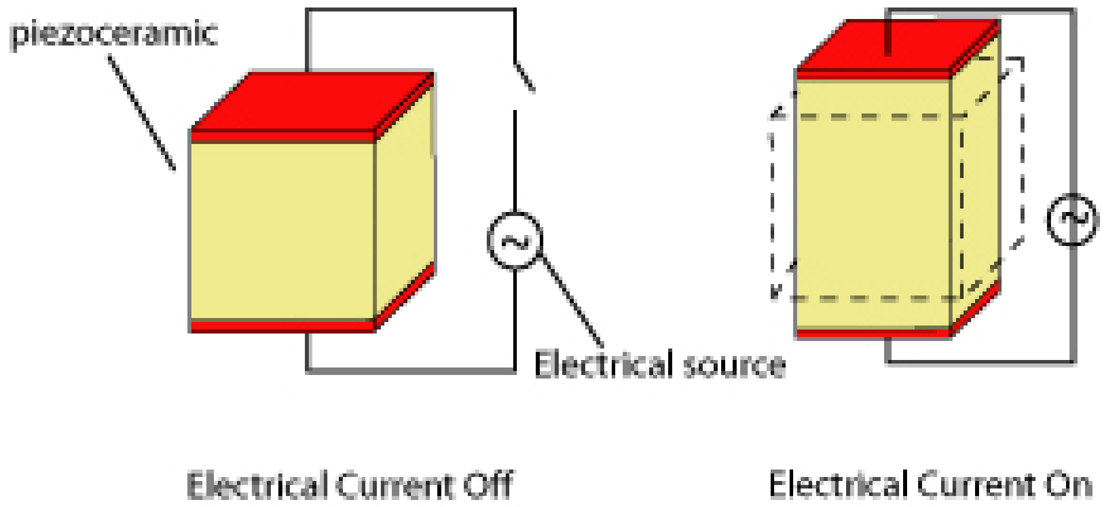
- The microscopic origin of the piezoelectric effect is the displacement of **ionic charges** within a crystal structure.
- In the absence of external strain, the charge distribution is symmetric and the net electric dipole moment is zero.
- However when an external stress is applied, the charges are displaced and the charge distribution is no longer symetric and a net polarization is created.

Piezoelectricity

- In some cases a crystal posses a unique polar axis even in the unstrained condition.
- This can result in a change of the electric charge due to a uniform change of temperature.
- This is called the ***pyroelectric effect***.
- The direct piezoelectric effect is the basis for force, pressure, vibration and acceleration sensors and
- The converse effect for actuator and displacement devices.

Piezo transducers

- Detect motion (high and low frequency)
- Sound (lab this week), pressure, fast motion
- Cheap, reliable but has a very limited range of motion



Photoelectric Transducer

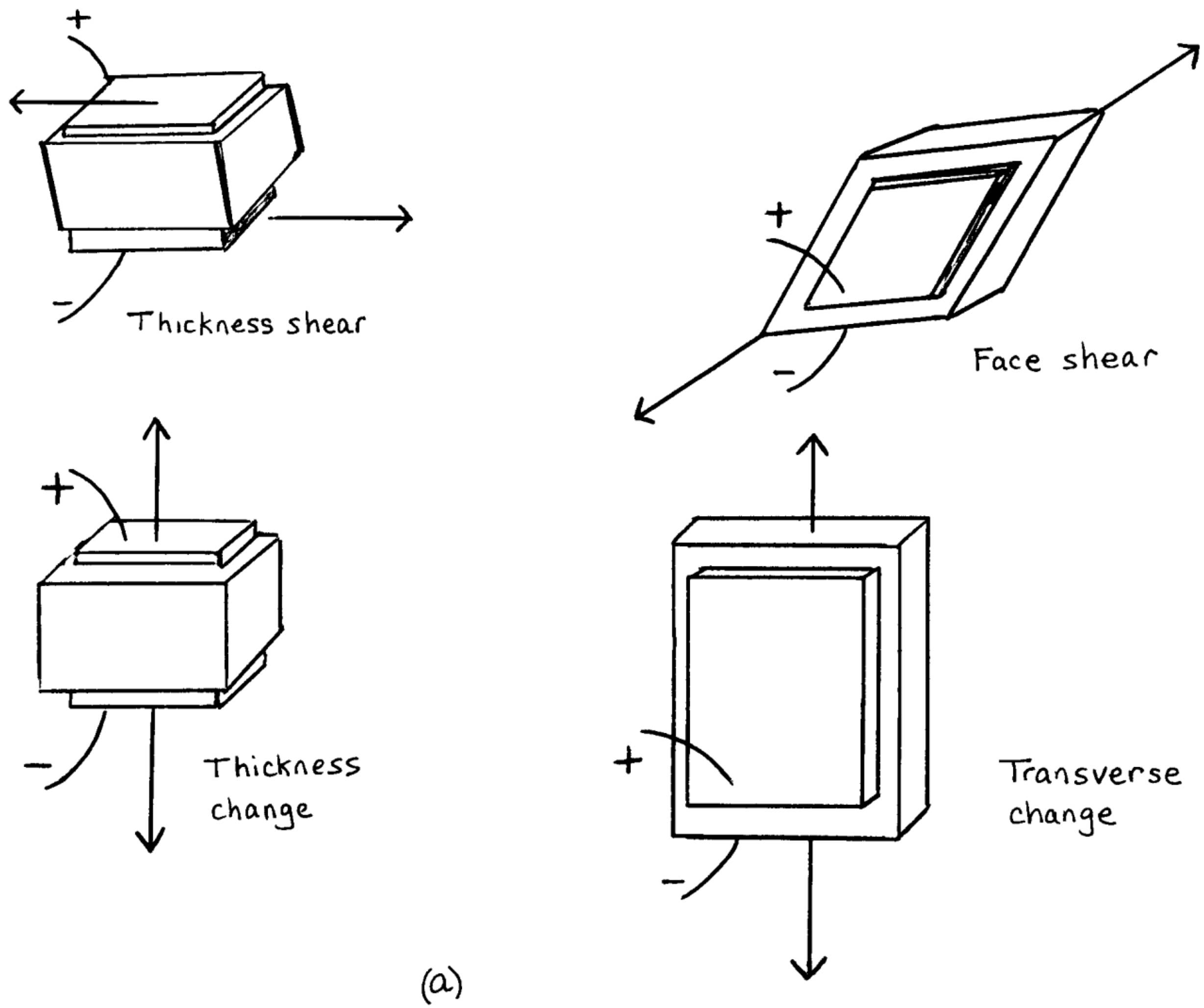
Can be categorized as: photoemissive, photoconductive, or photovoltaic.

No.	Types	Characteristics
1.	Photoemmisive	radiation falling into a cathode causes electrons to be emitted from cathode surface.
2.	Photoconductive	the resistance of a material is change when it’s illuminated.
3.	Photovoltaic	Generate an output voltage proportional to radiation intensity

- **Examples of Photoelectric Transducer**

- (i) The Photomultiplier Tube
- (ii) Photoconductive Cells OR Photocells
  the electrical resistance of the materials varies with the amount of light striking.
- (iii) The Photovoltaic Cell or solar cell
  - produce an electrical current when connected to the load.

Models of Piezoelectric Sensors



Piezoelectric polymeric films, such as polyvinylidence fluoride (PVDF). Used for uneven surface and for microphone and loudspeakers.

Thank You