

Unit – 3

Transducers

Lecture_3.1

Introduction to Transducers

Introduction to transducers

- A transducer is a device that converts one form of energy to other form. It converts the measurand to a usable electrical signal.
- In other word it is a device that is capable of converting the physical quantity into *a proportional electrical quantity such as voltage or current.*
 - The physical quantity may be mechanical, chemical, optical or thermal.
- Transducers are classified based on,
 - Application.
 - Method of energy conversion.
 - Nature of output signal.

Classification of transducers

The transducers can be classified as:

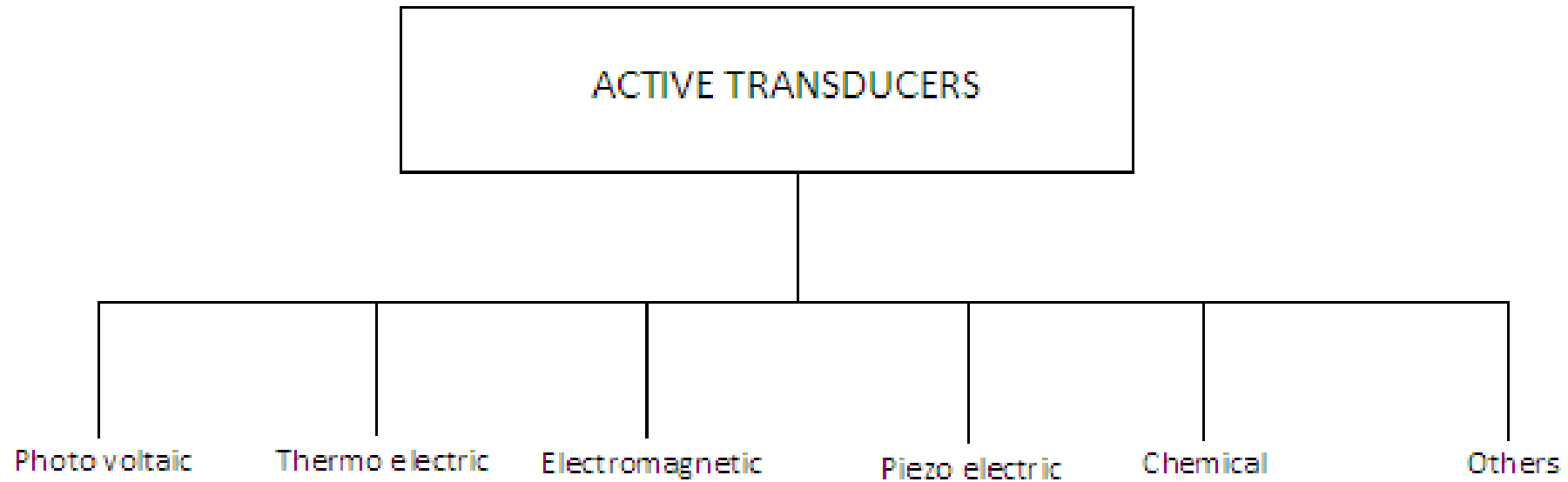
- I. Active and passive transducers.
 - II. Analog and digital transducers.
 - III. On the basis of transduction principle used.
 - IV. Primary and secondary transducer
 - V. Transducers and inverse transducers.
- **Electrical transducers**
 - voltage, current, frequency.
 - R, C, I component and its effects.
 - **Non-electrical transducers**
 - Detector (*sensor*).
 - Physical quantity is obtained which is converted to electrical quantity.
 - **Displacement transducers**
 - Capacitive, oscillation, potentiometric, photoelectric, piezoelectric (*Force Summing Devices*).
 - **Opto-electronic transducers**
 - Converts light energy into electrical energy.
 - Photoconductive cell, photovoltaic cell, solar cell, photo tube, photo multiplier, etc.

Active Transducers

These transducers do not need any external source of power for their operation. Therefore they are also called as self generating type transducers.

- The active transducer are self generating devices which operate under the energy conversion principle.
- As the output of active transducers we get an equivalent electrical output signal e.g. temperature or strain to electric potential, without any external source of energy being used.

Classification of Active transducers

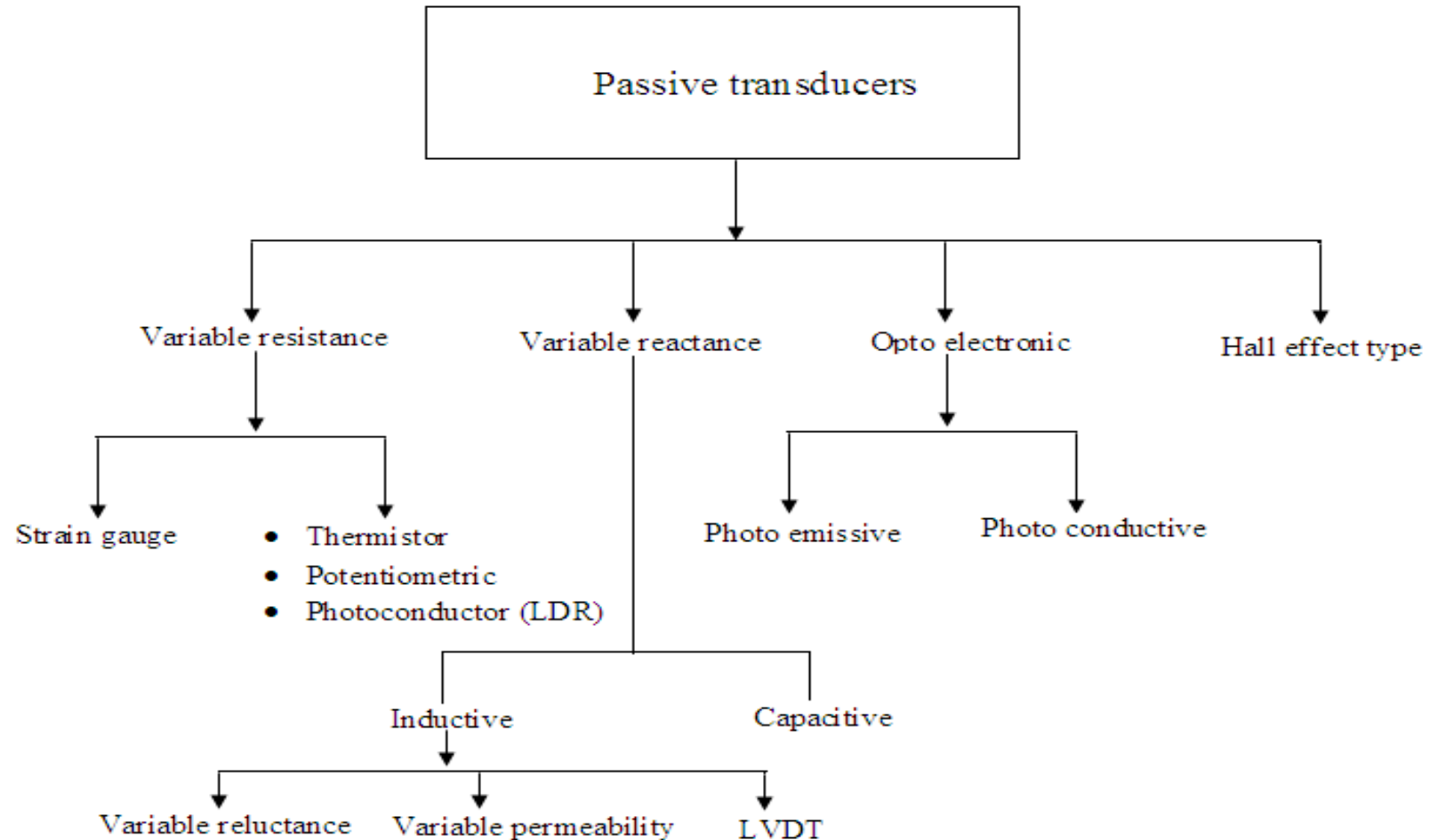


Passive Transducers

These transducers need external source of power for their operation. So they are not self generating type transducers.

- A DC power supply or an audio frequency generator is used as an external power source.
- These transducers produce the output signal in the form of variation in resistance, capacitance, inductance or some other electrical parameter in response to the quantity to be measured.

Classification of Passive transducers



Active and Passive transducers

Active Transducers

- Self-generating type.
- Energy for generating output is obtained from physical phenomenon.
 - Thermocouple
 - Piezoelectric transducer
 - Photovoltaic cell
 - Photoelectric (photoemission) cell

Passive Transducers

- Externally powered.
- Resistance type
 - Strain gauge
 - Potentiometric device
 - Thermistor
- Inductive type
 - LVDT
- Capacitive type
 - Hall effect transducer

Basic requirements of a transducer

- **Linearity** – characteristics between input and output.
- **Ruggedness** – ability to withstand overload and protection measures.
- **Repeatability** – ability to produce same output for same input at different times and environment.
- **High stability & reliability** – output should not be affected by temperature, vibration, other environmental conditions, with minimal error.
- **Good dynamic response** – ability to change output quickly for dynamic variation in input with respect to time.
- **Convenient instrumentation** – high analog output, high SNR, direct measurement or after amplification.
- **Good mechanical characteristics** – ability to withstand deformation and deterioration in performance caused by various mechanical strains.

Resistive Transducer

- Resistive transducers are those transducers in which the resistance change due to the change in some physical phenomenon.
- The resistance of a metal conductor is expressed by a simple equation.

$$R = \rho L/A$$

Where R = resistance of conductor in Ω

L = length of conductor in m

A = cross sectional area of conductor in m^2

ρ = resistivity of conductor material in Ω -m.

Capacitive Transducer

- In capacitive transduction transducers the measurand is converted to a change in the capacitance.
- The relationship between the capacitance and the size of capacitor plate, amount of plate separation, and the dielectric is given by

$$C = \epsilon_0 \epsilon_r A / d$$

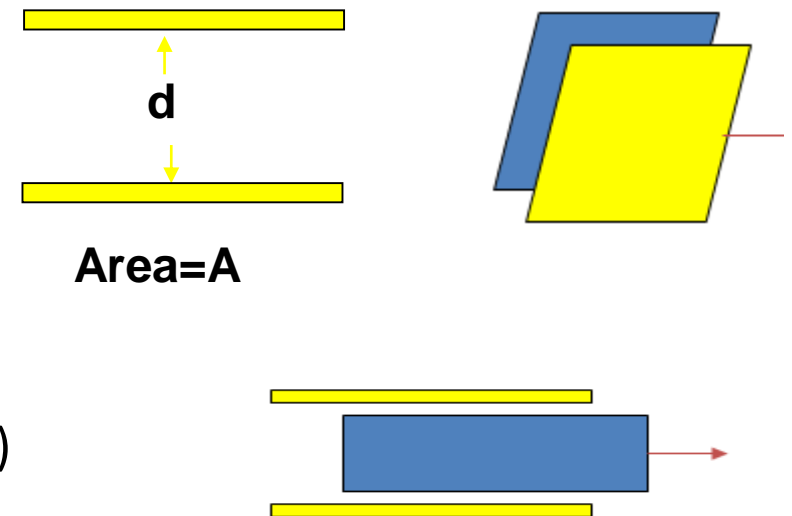
d is the separation distance of plates (m)

C is the capacitance (F, Farad)

ϵ_0 : absolute permittivity of vacuum

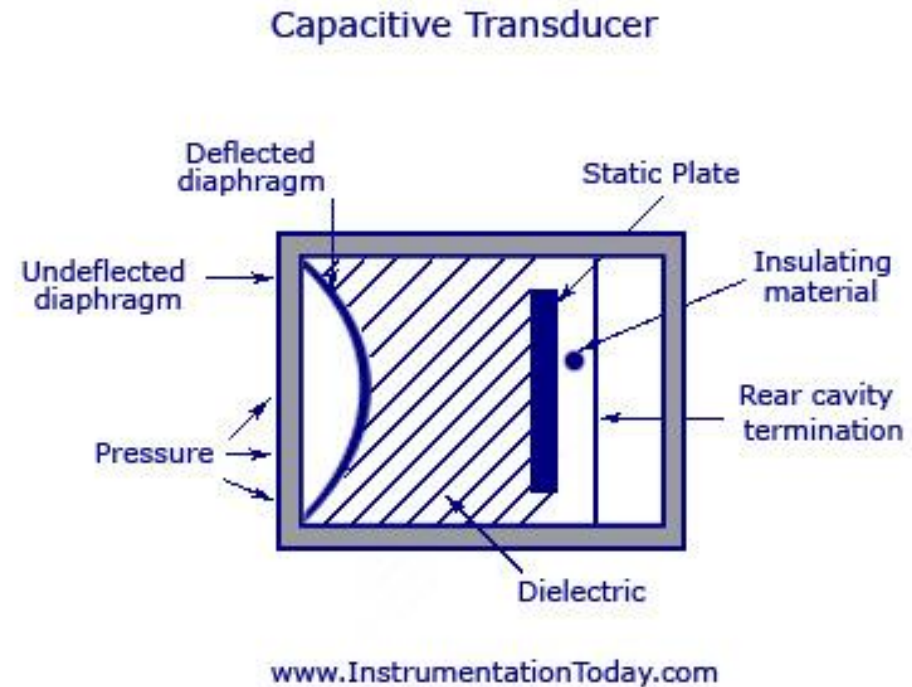
ϵ_r : relative permittivity

A is the effective (overlapping) area of capacitor plates (m²)



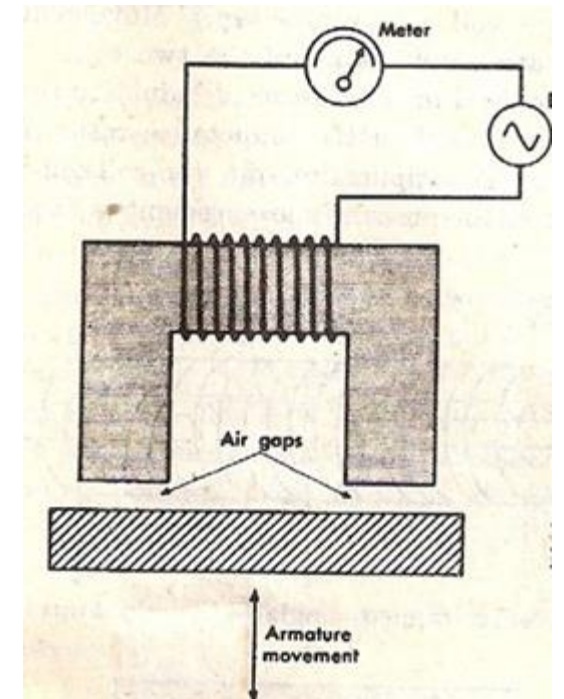
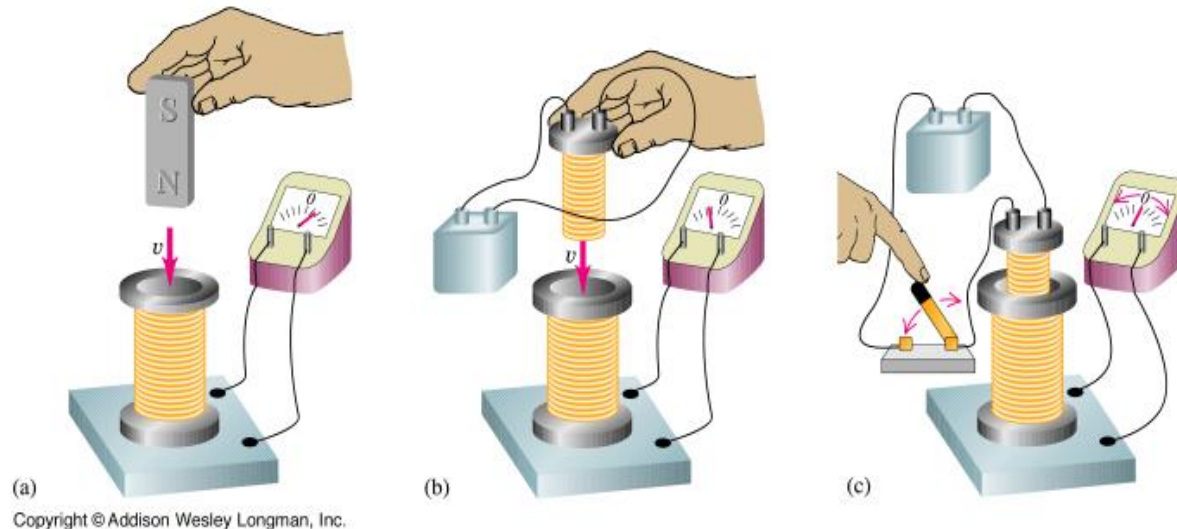
Capacitive Transducer

- A movable diaphragm forms one plate of the capacitor.
- The distance between diaphragm and static plate changes when a force applied to the diaphragm.
- The change in capacitance is measured with an ac bridge circuit or oscillator circuit as change in frequency.
- Can measure both static and dynamic changes.
- *Drawback* → Sensitivity to temperature variations



Inductive Transducer

- When a force is applied to the ferromagnetic armature, the air gap changes, varying the reluctance of the magnetic circuit.
- Applied force is measure as change of inductance in the coil.
- Can measure both static and dynamic changes.
- *Drawback* → Limited frequency response.



Video Segment_4



Video Signal_5

