Chapter 2
Sensors and Transducers

Transducers

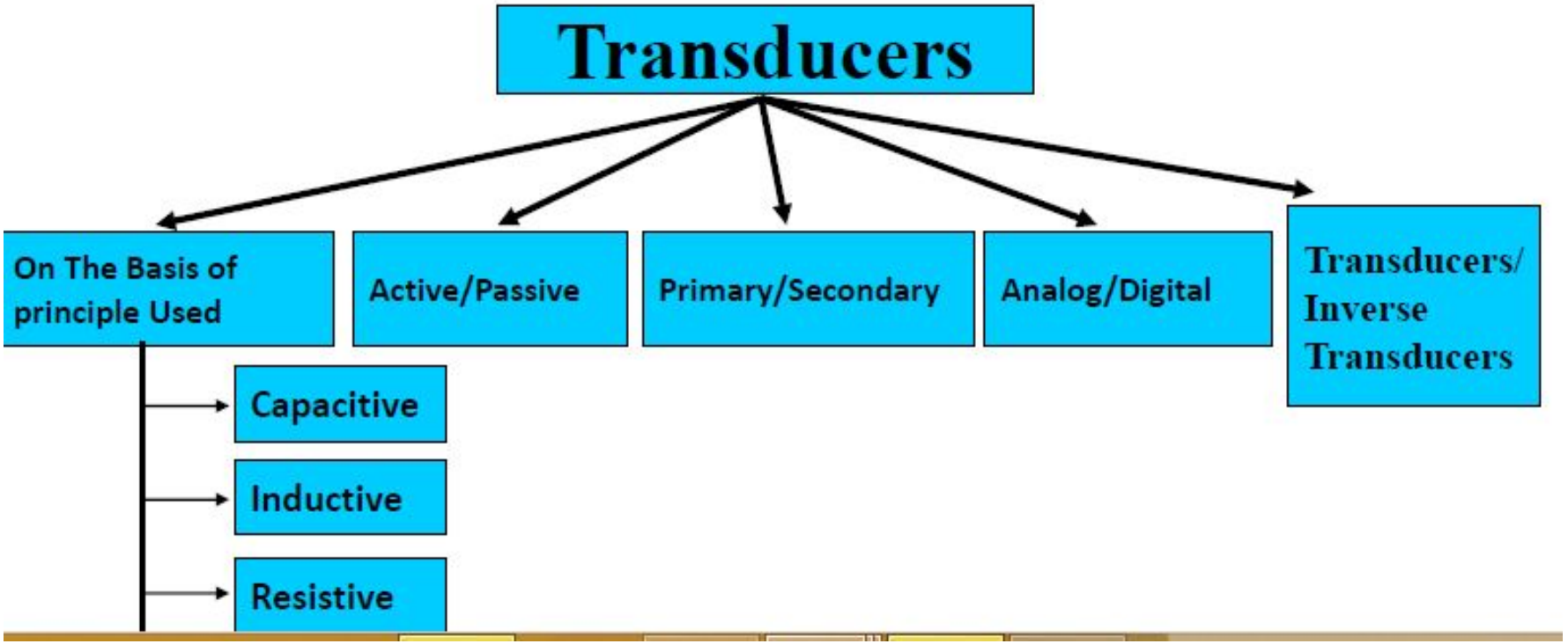
- A Transducer is a device which converts one form of energy into another form.

- Alternatively, a Transducer is defined as a device which provides usable output response to a specific input measured which may be a physical quantity.

- A Transducer can also be defined as a device when actuated by energy in one system supplies energy in the same form or in another form to a second system

Classification of Transducers

- Transducers may be classified according to their application, method of energy conversion, nature of the output signal, and so on.



Classification of Transducers

- **Based on the physical phenomenon**

(*a) Primary transducer*

(*b) Secondary transducer*

- **Based on the power type**

(*a) Active transducer*

(*b) Passive transducer*

- **Based on the type of output**

(*a) Analog transducer*

(*b) Digital transducer*

Classification of Transducers

- **Based on the electrical phenomenon**

(*a) Resistive transducer*
(*b) Capacitive transducer*
(*c) Inductive transducer*
(*d) Photoelectric transducer*
(*e) Photovoltaic transducer*

- **Based on the non-electrical phenomenon**

(*a) Linear displacement*
(*b) Rotary displacement*

- **Based on the transduction phenomenon,**

(*a) Transducer*
(*b) Inverse transducer*

Active and Passive Transducers

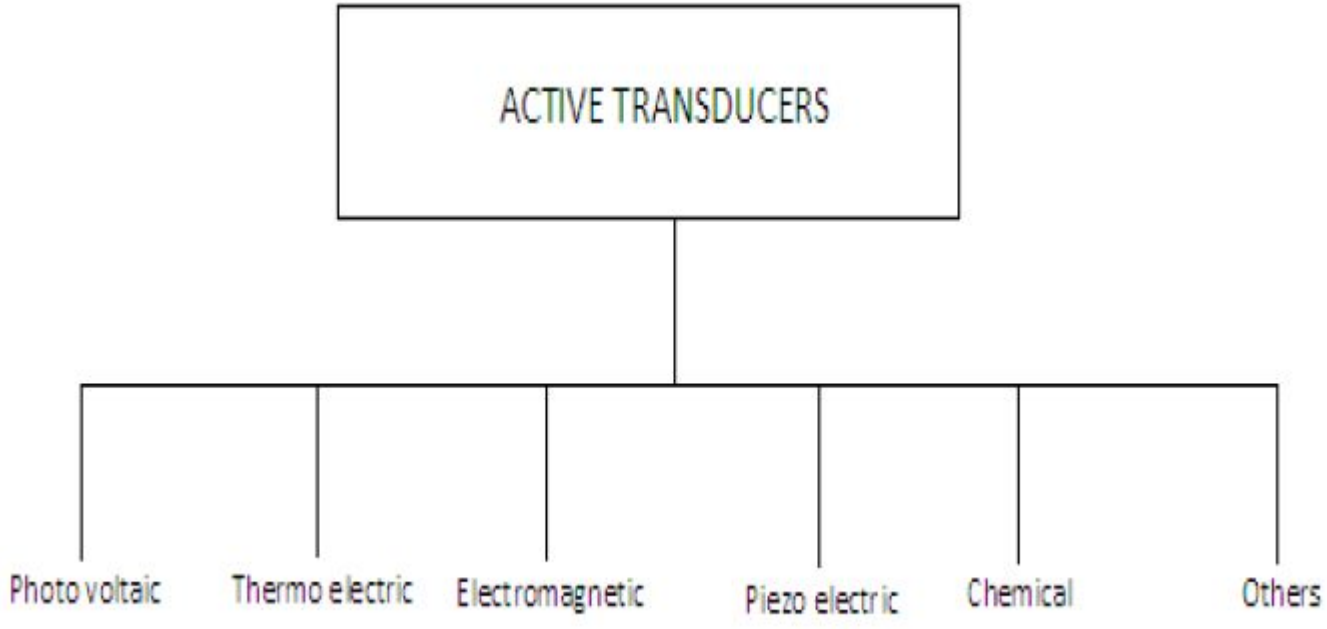
Active transducers :

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

I. The active transducer are self generating devices which operate under the energy conversion principle.

II. 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 electrical parameter like resistance, capacitance or inductance.

Examples – Thermistor, Potentiometer type transducer

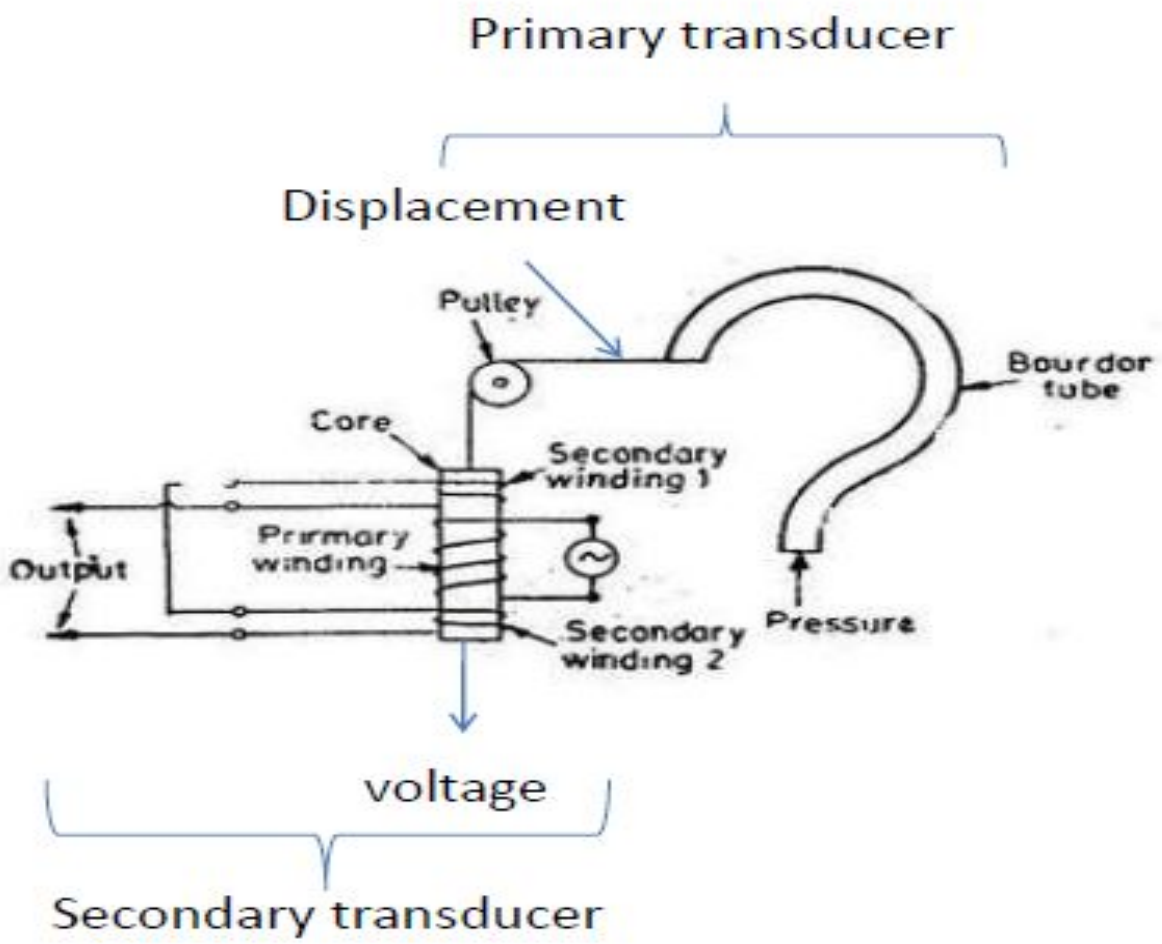
Primary and Secondary Transducers

- Some transducers contain the mechanical as well as electrical device.

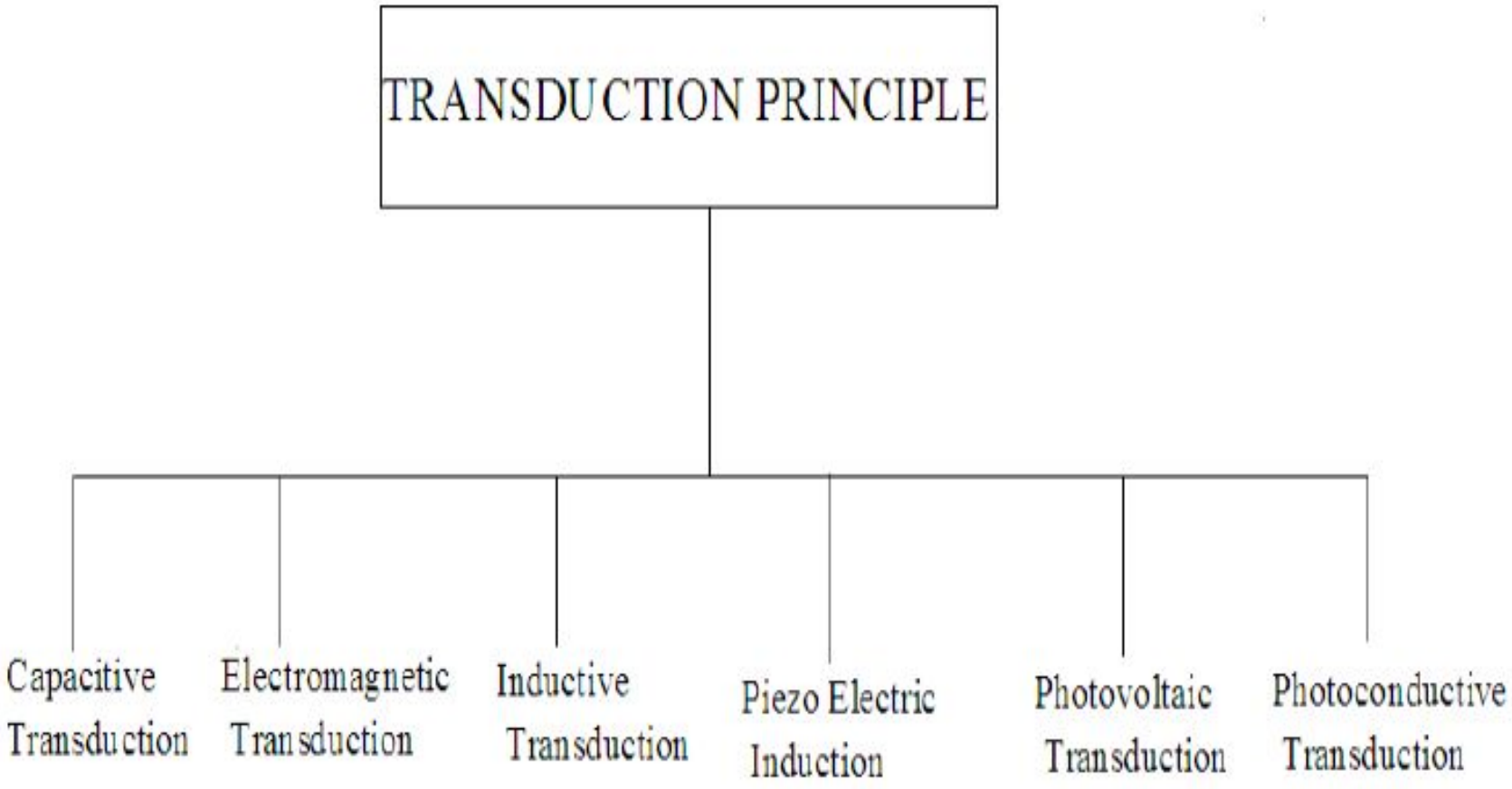
- The mechanical device converts the physical quantity to be measured into a mechanical signal. Such mechanical device are called as the primary transducers, because they deal with the physical quantity to be measured.

- The electrical device then convert this mechanical signal into a corresponding electrical signal. Such electrical device are known as secondary transducers.

Example of Primary and secondary transducer



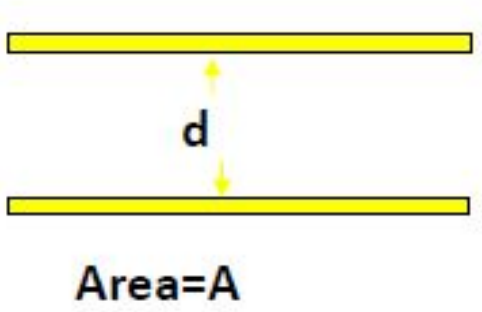
According to Transduction principle used



Capacitive Transduction

The measurand is converted into a change in capacitance.

- A change in capacitance occurs either by changing the distance between the two plates or by changing the dielectric.



Electromagnetic transduction

- In electromagnetic transduction, the measurand is converted to voltage induced in conductor by change in the magnetic flux, in absence of excitation.
- The electromagnetic transducer are self generating active transducers
- The motion between a piece of magnet and an

electromagnet is responsible for the change in flux

Analog and Digital Transducers

Analog transducers

• These transducers convert the input quantity into an analog output which is a continuous function of time.

• Thus a **strain gauge, an L.V.D.T., a thermocouple or a thermistor may be called as Analog Transducers as they** give an output which is a continuous function of time.

Digital Transducers:

• These transducers convert the input quantity into an electrical output which is in the form of pulses and its output is represented by 0 and 1.

Transducer and Inverse Transducer

- Transducer:

Transducers convert non electrical quantity to electrical quantity.

- Inverse Transducer:

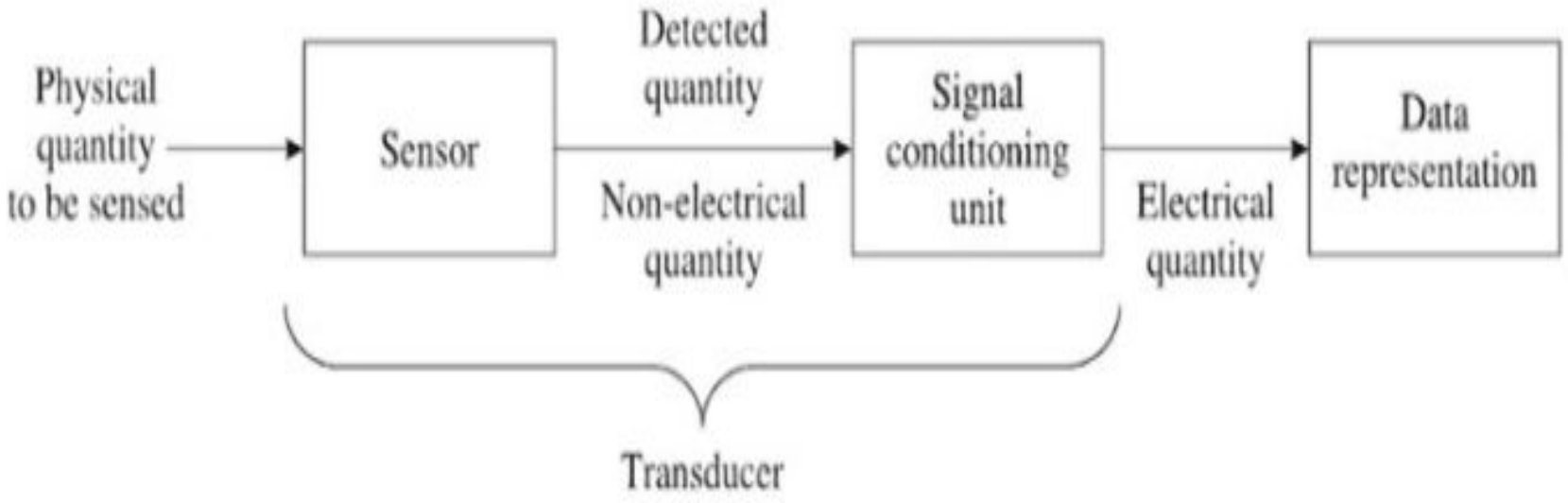
Inverse transducers convert electrical quantity to a non electrical quantity.

Selection Criteria for Transducers

The following factors are to be considered while selecting a transducer for further applications.

- Operating range : The range of transducer should be appropriate for measurement to get a good resolution.
- Operating Principle : The transducers are selected on the basis of operating principle it may be resistive, inductive, capacitive, optical etc.
- Accuracy : The accuracy should be as high as possible or as per the measurement.
- Range : The transducer can give good result within its specified range, so select transducer as per the operating range.
- Sensitivity : The transducer should be more sensitive to produce the output or sensitivity should be as per requirement.
- Environmental compatibility : The transducer should maintain input and output characteristic for the selected environmental condition.
- Loading effect: The transducer's input impedance should be high and output impedance should be low to avoid loading effect.
- Errors : The error produced by the transducer should be low as possible.

Basic Block Diagram



- **Sensor**
- **Signal Conditioning Unit**
- **Data Representing Device**

- **Sensor**
- A Sensor is a device that is used to detect changes in any physical quantity like Temperature, Speed, Flow, Level, Pressure, etc.
- Any changes in the input quantity will be detected by a Sensor and reflected as changes in output quantity.
- Both the input and output quantities of a Sensor are Physical i.e. non-electrical in nature.

- **Signal Conditioning Unit**
- The Signal Conditioning Unit is used to convert the physical output (or non-electrical output) of the sensor to an electrical quantity.

Some Signal conditioning units are:

- Analog to Digital Converters
- Amplifiers
- Filters
- Rectifiers

- **Data Representation Device**
- A Data representation device is used to present the measured output to the observer. This can be :
- A Scale
- An LCD Display
- A Signal Recorder

Characteristics of Transducer

1. **Accuracy**: It is defined as the closeness with which the reading approaches an accepted standard value or ideal value or true value, of the variable being measured.

2. **Ruggedness**: The transducer should be mechanically rugged to withstand overloads. It should have overload protection.

3. **Linearity**: The output of the transducer should be linearly proportional to the input quantity under measurement. It should have linear input - output characteristic. -
4. **Repeatability:** The output of the transducer must be exactly the same, under same environmental conditions, when the same quantity is applied at the input repeatedly.

High output: The transducer should give reasonably high output signal so that it can be easily processed and measured. The output must be much larger than noise. Now-a-days, digital output is preferred in many applications;

High Stability and Reliability: The output of the transducer should be highly stable and reliable so that there will be minimum error in measurement. The output must remain unaffected by environmental conditions such as change in temperature, pressure, etc.

7. **Sensitivity**: The sensitivity of the electrical transducer is defined as the electrical output obtained per unit change in the physical parameter of the input quantity. For example, for a transducer used for temperature measurement, sensitivity will be expressed in mV/’ C. A high sensitivity is always desirable for a given transducer.

8. **Dynamic Range:** For a transducer, the operating range should be wide, so that it can be used over a wide range of measurement conditions.

9. **Size:** The transducer should have smallest possible size and shape with minimal weight and volume. This will make the measurement system very compact.

10. **Speed of Response:** It is the rapidity with which the transducer responds to changes in the measured quantity. The speed of response of the transducer should be as high as practicable.