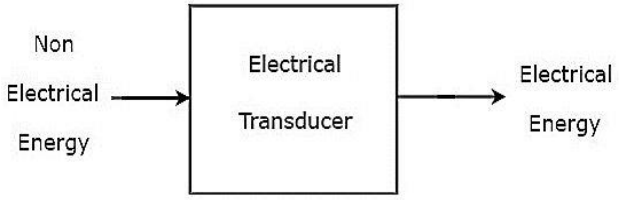
MODULE -4

TRANSDUCERS

- **Transducer converts one form of energy into another form of energy. The transducer, which converts non-electrical form of energy into electrical form of energy is known as electrical transducer**



- **Electrical transducer will produce an output, which has electrical energy.**
- **The output of electrical transducer is equivalent to the input, which has non-electrical energy**.

TYPES OF TRANSDUCERS

Mainly, the electrical transducers can be classified into the following two types.

1. **Active Transducers**
2. **Passive Transducer**

- **Active Transducers**
- **The transducer, which can produce one of the electrical quantities such as voltage and current is known as active transducer.**
- **It is also called self-generating transducer, since it doesn't require any external power supply.**
- **Active transducer will produce an electrical quantity (or signal), which is equivalent to the non-electrical input quantity (or signal).**

Following are the examples of active transducers.

- **Piezo Electric Transducer**
- **Photo Electric Transducer**
- **Thermo Electric Transducer**

- **Passive Transducers**
- **The transducer, which can't produce the electrical quantities such as voltage and current is known as passive transducer.**
- **But, it produces the variation in one of passive elements like resistor (R), inductor (L) and capacitor (C).**
- **Passive transducer requires external power supply**
- **Passive transducer will produce variation in the passive element in accordance with the variation in the non-electrical input quantity (or signal).**

Following are the examples of passive transducers.

- **Resistive Transducer**
- **Inductive Transducer**
- **Capacitive Transducer**

ADVANTAGES

- **The attenuation and amplification of the electrical signals are very easy.**
- **The electrical signal produces less friction error.**
- **The small power is required for controlling the electrical systems.**
- **The electrical signals are easily transmitted and processed for measurement.**
- **The component used for measuring the electrical signal is very compact and accurate.**
- **The electrical signals are used in telemetry**.

Factors Influencing the Choice of Transducer

1. **Operating Principle – The transducers are selected by their operating principles. The operating principle may be resistive, inductive, capacitive, optoelectronic, piezoelectric, etc.**
2. **Sensitivity – The sensitivity of the transducer is enough for inducing the detectable output.**
3. **Operating Range – The transducer must have wide operating ranges so that it does not break during the working.**
4. **Accuracy – The transducers gives accuracy after calibration. It has a small value for repeatability which is essentials for the industrial applications.**
5. **Cross Sensitivity – The transducers gives variable measured value for the different planes because of the sensitivity. Hence, for the accurate measurement, the cross sensitivity is essential.**
6. **Errors – The errors are avoided by taking the input output relations which is obtained by the transfer function.**
7. **Loading Effect – The transducers have high input impedance and low output impedance for avoiding the errors.**
8. **Environmental Compatibility – The transducers should be able to work in any specified environments like in a corrosive**

environment. It should be able to work under high pressure and shocks.

9. Insensitivity to Unwanted Signals – The transducer should be sensitive enough for ignoring the unwanted and high sensitive signals.
10. Usage and Ruggedness – The durability, size and weight of the transducer must be known before selecting it.
11. Stability and Reliability – The stability of the transducers should be high enough for the operation. And their reliability should be good in case of failure of the transducer.

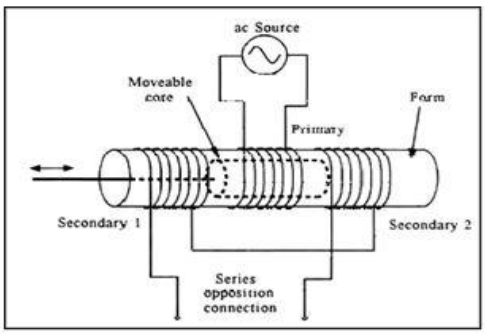
Applications of Transducer

- It is used for detecting the movement of muscles which is called acceleromyograph.
- The transducer measures the load on the engines.
- The transducers measure the pressure of the gas and liquid by converting it into an electrical signal.
- It converts the temperature of the devices into an electrical signal or mechanical work.
- The transducer is used in the ultrasound machine. It receives the sound waves of the patient by emitting their sound waves and pass the signal to the CPU.
- The transducer is used in the speaker for converting the electrical signal into acoustic sound.
- It is used in the antenna for converting the electromagnetic waves into an electrical signal.

LVDT

- LVDT stands for the Linear Variable Differential Transformer.
- It is the most widely used inductive transducer that converts the linear motion into the electrical signal.
- The output across secondary of this transformer is the differential thus it is called so.
- It is very accurate inductive transducer as compared to other inductive transducers

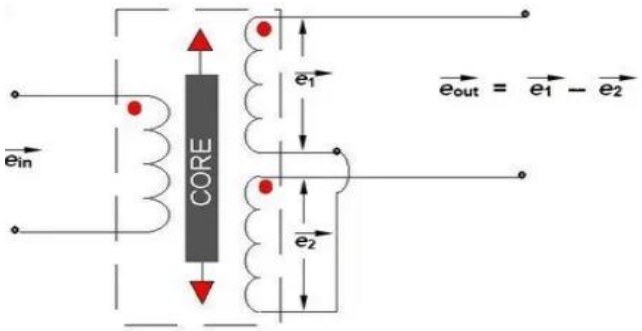
Construction of LVDT



Main Features of Construction

- The transformer consists of a primary winding P and two secondary windings S_1 and S_2 wound on a cylindrical former (which is hollow in nature and contains the core).
- Both the secondary windings have an equal number of turns, and we place them on either side of primary winding
- The primary winding is connected to an AC source which produces a flux in the air gap and voltages are induced in secondary windings.
- A movable soft iron core is placed inside the former and displacement to be measured is connected to the iron core.
- The iron core is generally of high permeability which helps in reducing harmonics
- The both the secondary windings are connected in such a way that resulted output is the difference between the voltages of two windings.

Principle of Operation and Working



As the primary is connected to an AC source so alternating current and voltages are produced in the secondary of the LVDT. The output in secondary S_1 is e_1 and in the secondary S_2 is e_2. So the differential output is,

$$e_{out} = e_1 - e_2$$

This equation explains the principle of Operation of LVDT

- CASE I When the core is at null position (for no displacement)
  When the core is at null position then the flux linking with both the secondary windings is equal so the induced emf is equal in both the windings. So for no displacement the value of output e_{out} is zero as e_1 and e_2 both are equal. So it shows that no displacement took place.
- CASE II When the core is moved to upward of null position (For displacement to the upward of reference point)
  In the this case the flux linking with secondary winding S_1 is more as compared to flux linking with S_2. Due to this e_1 will be more as that of e_2. Due to this output voltage e_{out} is positive
- CASE III When the core is moved to downward of Null position (for displacement to the downward of the reference point). In this case

magnitude of e_2 will be more as that of e_1. Due to this output e_{out} will be negative.

- **By noting the output voltage increasing or decreasing the direction of motion can be determined**
- **The output voltage of an LVDT is linear function of core displacement .**

Advantages of LVDT

- **High Range – The LVDTs have a very high range for measurement of displacement.they can used for measurement of displacements ranging from 1.25 mm to 250 mm**
- **No Frictional Losses – As the core moves inside a hollow former so there is no loss of displacement input as frictional loss so it makes LVDT as very accurate device.**
- **High Input and High Sensitivity – The output of LVDT is so high that it doesn't need any amplification. The transducer posseses a high sensitivity which is typically about 40V/mm.**
- **Low Hysteresis – LVDTs show a low hysteresis and hence repeatability is excellent under all conditions**
- **Low Power Consumption – The power is about 1W which is very as compared to other transducers.**
- **Direct Conversion to Electrical Signals – They convert the linear displacement to electrical voltage which are easy to process**

Disadvantages of LVDT

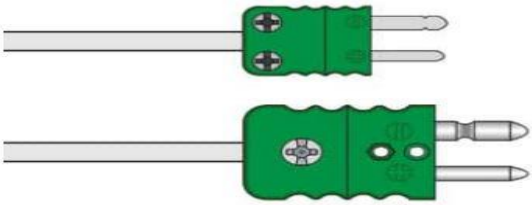
- **LVDT is sensitive to stray magnetic fields so it always requires a setup to protect them from stray magnetic fields.**
- **LVDT gets affected by vibrations and temperature.**

Applications of LVDT

- **We use LVDT in the applications where displacements to be measured are ranging from a fraction of mm to few cms. The LVDT acting as a primary transducer converts the displacement to electrical signal directly.**
- **The LVDT can also act as a secondary transducer. E.g. the Bourbon tube which acts as a primary transducer and it converts pressure into linear displacement and then LVDT coverts this displacement into an electrical signal which after calibration gives the readings of the pressure of fluid.**

THERMOCOUPLE

- **A thermocouple is a device for measuring temperature. It comprises two dissimilar metallic wires joined together to form a junction.**
- **When the junction is heated or cooled, a small voltage is generated in the electrical circuit of the thermocouple which can be measured, and this corresponds to temperature.**
- **In theory, any two metals can be used to make a thermocouple but in practise, there are a fixed number of types that are commonly used. They have been developed to give improved linearity and accuracy and comprise specially developed alloys.**
- **Thermocouples can be made to suit almost any application. They can be made to be robust, fast responding and to measure a very wide temperature range**
- **A thermocouple is simply a sensor that is used for measuring temperature. This design of sensor consists of two dissimilar metal wires which are joined together at one end, connected to an instrument that is capable of accepting a thermocouple input and measure the reading.**
- **Thermocouples can provide temperature measurements over a wide spectrum of temperatures dependent on which thermocouple type you use.**



Thermocouple diagram

THERMISTORS

- **A thermistor, a shortened version of the term thermal resistor, is a passive component whose resistance changes as the temperature in a system changes.**
- **Thus they serve as an inexpensive, accurate, and dynamic method for measuring temperature. The amount of resistance of a thermistor is dependent on the materials used to produce them.**

- **Thermistors are used to monitor the temperature surrounding a device and temperature changes in a device.**

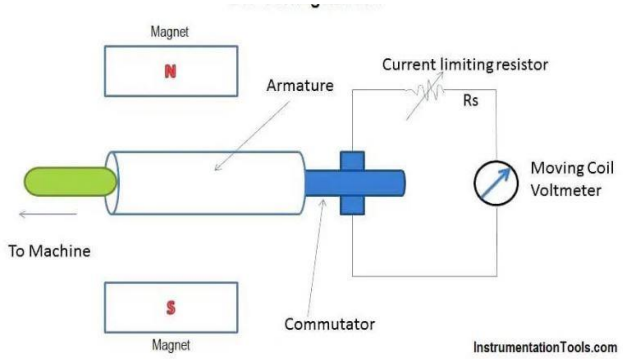
- **Changes in temperature, detected by a thermistor, influences equipment and is used for temperature sensing and overload cut outs.**
- **Thermistors can be found in an assortment of circuits, equipment, and devices providing a low cost method for temperature measurement**

APPLICATIONS

1. **Measurement and control of temparature**
2. **It is used for the measurement of high-frequency power.**
3. **The thermistor measures the thermal conductivity.**
4. **The thermistor measures the pressure of the liquid.**
5. **It measures the composition of gases.**
6. **The thermistor measures the vacuum and provides the time delays.**

DC TACHO GENERATOR

- **The D.C Tachogenerator is a type of electrical type's tachogenerators which can also be used for speed measurement.**
- **The armature of the D.C Tachogenerator is kept in the permanent magnetic field. The armature of the tachogenerator is coupled to the machine whose speed is to be measured.**
- **When the shaft of the machine revolves, the armature of the tachogenerator revolves in the magnetic field producing e.m.f. which is proportional to the product of the flux and speed to be measured.**
- **The field of the permanent field is fixed, the e.m.f generated is proportional to the speed directly. The e.m.f induced is measured using moving coil voltmeter with uniform scale calibrated in speed directly.**
- **The series resistance is used to limit the current under output short circuit condition. The polarity of output voltage indicates the direction of rotation.**
- **The commutator collects current from armature conductors and converts internally induced a.c e.m.f into d.c (unidirectional) e.m.f. while the brushes are used to collect current from commutator and make it available to external circuitry of the d.c tachogenerator.**



ADVANTAGES

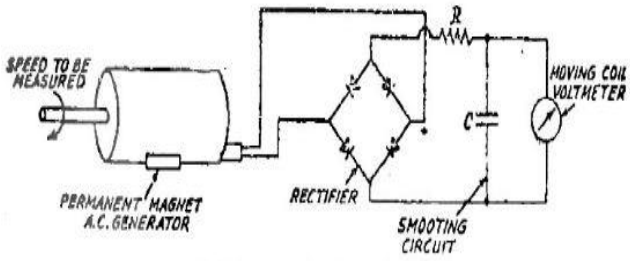
- **The output voltage is small enough to measure it with conventional d.c voltmeters.**
- **The polarity of output voltage directly indicates the direction of rotation**

DISADVANTAGES

- **Because of variations in contact resistance, considerable error is introduced in the output voltage. Hence periodic maintenance of the commutator and brushes is required.**

AC TACHO GENERATOR

- **The AC tachogenerator is used to measure the speed only in one direction.**
- **In AC tachogenerator the armature is provided with an AC winding, either single phase or three phase windings**.



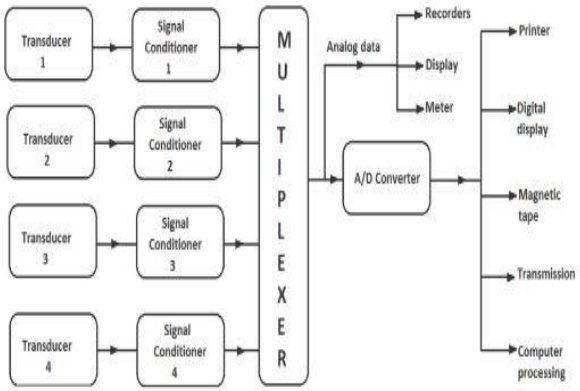
A.C. Tachometer Generator.

- **When the rotor is stationary and primary winding excited by an AC input voltage, the induced voltage in secondary is zero.**
- **Due to relative position of two winding being placed at 90^0 to each other. As the rotor rotates, a voltage is induced in the secondary winding**

whose magnitude is propertional to the rotor speed.

DATA ACQUISITION SYSTEM

- **The systems, used for data acquisition are known as data acquisition systems. These data acquisition systems will perform the tasks such as conversion of data, storage of data, transmission of data and processing of data.**



Generalised Data Acquisition System

Data acquisition systems consider the following analog signals.

- **Analog signals, which are obtained from the direct measurement of electrical quantities such as DC & AC voltages, DC & AC currents, resistance and etc.**
- **Analog signals, which are obtained from transducers such as LVDT, Thermocouple & etc.**