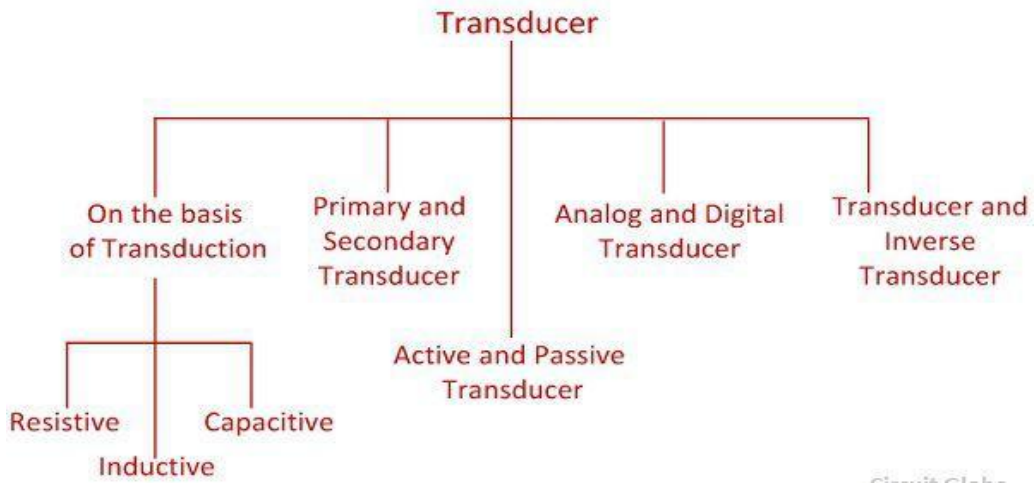
Module 4 Control instruments and their applications

Transducer

- An **electrical transducer** is a device which is capable of converting physical quantities into a proportional electrical quantity such as voltage and current

Classifications of Transducer



1. Classification based on the Principle of Transduction

The transducer is classified by the transduction medium. The transduction medium may be resistive, inductive or capacitive depends on the conversion process that how input transducer converts the input signal into resistance, inductance and capacitance respectively.

2. Primary and Secondary Transducer

Primary Transducer – The transducer consists the mechanical as well as the electrical devices. The mechanical devices of the transducer change the physical input quantities into a mechanical signal. This mechanical device is known as the primary transducers.

Secondary Transducer – The secondary transducer converts the mechanical signal into an electrical signal. The magnitude of the output signal depends on the input mechanical signal.

3. Passive and Active Transducer

Passive Transducer – The transducer which requires the power from an external supply source is known as the passive transducer. They are also known as the external power transducer. The capacitive, resistive and inductive transducers are the example of the passive transducer.

Active Transducer – The transducer which does not require the external power source is known as the active transducer. Such type of transducer develops theirs owns voltage or current, hence known as a self-generating transducer. The output signal is obtained from the physical input quantity.

4. Analog and Digital Transducer

Analog Transducer – The Analog transducer changes the input quantity into a continuous function. The strain gauge, L.V.D.T, thermocouple, thermistor are the examples of the analogue transducer.

Digital Transducer – These transducers convert an input quantity into a digital signal or in the form of the pulse. The digital signals work on high or low power.

5. Transducer and Inverse Transducer

Transducer – The device which converts the non-electrical quantity into an electric quantity is known as the transducer.

Inverse Transducer – The transducer which converts the electric quantity into a physical quantity, such type of transducers is known as the inverse transducer. The transducer has high electrical input and low non-electrical output.

Basic requirements of transducers

1, Ruggedness: It should be capable of withstanding over load and some safety should be provided for overload protection.

2, Linearity: Its input-output characteristics should be linear and it should produce these characteristics in symmetrical way.

3, Repeatability: It should reproduce same output signal when the same input signal is applied under fixed environmental conditions. For example pressure, temperature, humidity etc.

4, Residual Deformation: There should be no deformation on removal of input signal after long period of application.

5, No Hysteresis: It should not give any hysteresis during measurement while input signal is varied from its low value to high value and vice versa.

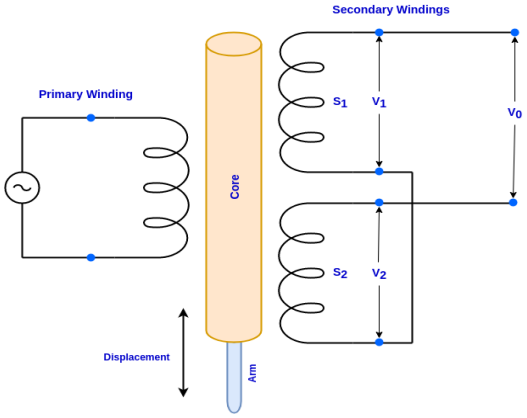
6, High Output Signal Quality: The quality of the output signal should be good. That is the ratio of signal to the noise is high and the amplitude of the output signal should be enough.

7, High Reliability and Stability: It should give minimum error in measurement for temperature variations, vibrations and other various changes in surroundings.

8, Good Dynamic Response: Its output should be faithful to input when taken as a function of time. The effect is analysed as the frequency response

LVDT (Linear Variable Differential Transformer)

It is a passive transducer, that works on the principle of mutual induction and can be used to measure displacement, pressure, and force.



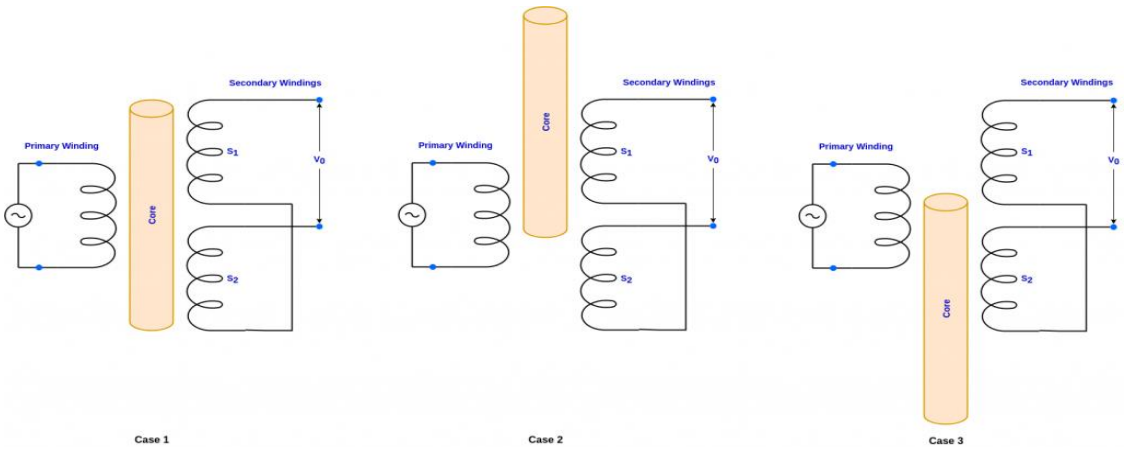
The primary winding is connected to an AC source. The two secondary winding S_1 and S_2 have an equal number of turns and are set up in series opposition. So the e.m.f induced in these winding are cancel each other

Operation of LVDT

When an alternating voltage input is given in the primary winding, an alternating emf is induced in the secondary winding(S_1 and S_2).

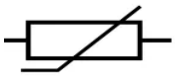
Suppose V_1 is the voltage induced across S_1 and V_2 is the voltage induced across S_2. The overall output voltage across the secondary winding(V_0) is the difference between V_1 and V_2. . Vo = V1 – V2

The value of V_0 depends on the position of the core. Three possible cases are illustrated in the following figure.

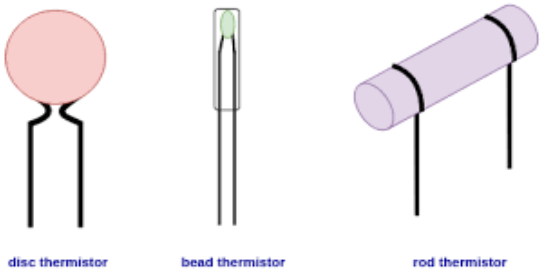


Thermistor

Thermistors act as a passive component in a circuit. It is used to measure temperature.



Symbol



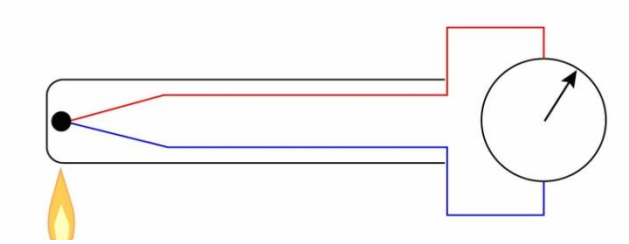
Uses of Thermistors

Thermistors have a variety of applications. They are widely used as a way to measure temperature as a thermistor thermometer in many different liquid and ambient air environments. Some of the most common uses of thermistors include:

- Digital thermometers (thermostats)
- Automotive applications (to measure oil and coolant temperatures in cars & trucks)
- Household appliances (like microwaves, fridges, and ovens)
- Circuit protection (i.e. surge protection)
- Rechargeable batteries (ensure the correct battery temperature is maintained)
- To measure the thermal conductivity of electrical materials
- Useful in many basic electronic circuits (e.g. as part of a beginner Arduino starter kit)
- Temperature compensation (i.e. maintain resistance to compensate for effects caused by changes in temperature in another part of the circuit)

Thermocouple

- A thermocouple is a transducer that converts thermal energy into electrical energy and is constructed by joining wires made from dissimilar metals to form a junction. Voltage is produced when the temperature at the junction changes.

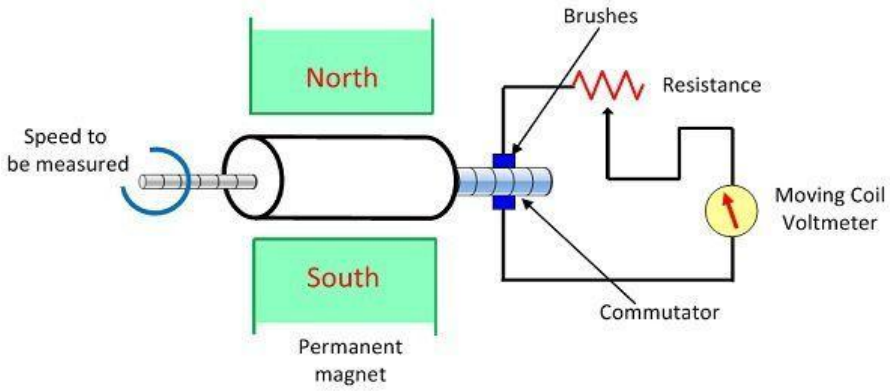


- The concept of the thermocouple is based on the Seebeck Effect, which states that if dissimilar metals are joined at a point they will generate a small measurable voltage when the temperature of the point of connection changes. The amount of voltage depends on the amount of temperature change and the characteristics of the metals.

DC Tachometer Generator

Permanent magnet, armature, commutator, brushes, variable resistor, and the moving coil voltmeter are the main parts of the DC tachometer generator. The machine whose speed is to be measured is coupled with the shaft of the DC tachometer generator.

The DC tachometer works on the principle that when the closed conductor moves in the magnetic field, EMF induces in the conductor. The magnitude of the induces emf depends on the flux link with the conductor and the speed of the shaft.



DC Tachometer Generator

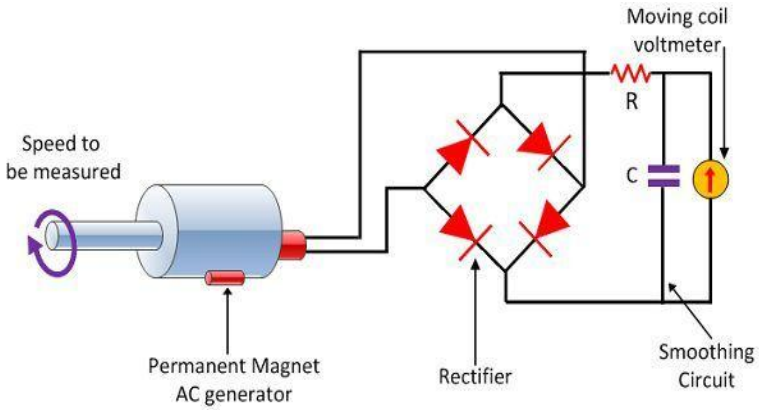
The armature of the DC generator revolves between the constant field of the permanent magnet. The rotation induces the emf in the coil. The magnitude of the induced emf is proportional to the shaft speed.

AC Tachometer Generator

The AC tachometer has stationary armature and rotating magnetic field. Thus, the commutator and brushes are absent in AC tachometer generator.

The rotating magnetic field induces the EMF in the stationary coil of the stator. The amplitude and frequency of the induced emf are equivalent to the speed of the shaft. Thus, either amplitude or frequency is used for measuring the angular velocity.

The below mention circuit is used for measuring the speed of the rotor by considering the amplitude of the induced voltage. The induced voltage is rectified and then passes to the capacitor filter for smoothening the ripples of rectified voltages.



A.C Tachometer Generator

Digital Tachometer

A tachometer measures the rotational speed of a disk or shaft, such as a motor, and expresses results in revolutions per minute (RPM).

One of the main benefits a digital tachometer has over its analogue counterparts is the ability to provide more precise and steady readings. Other significant advantages digital tachometers can have over analogue tachometers include; the ability to change units of measurement, recall last readings, and view minimum, maximum, and average measurements.

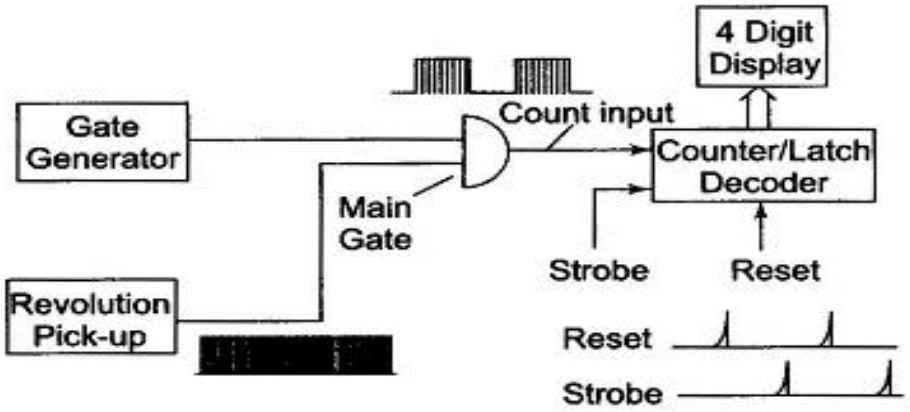


Fig. 6.19 Basic Block Diagram of a Digital Tachometer

Types of Digital Tachometers

1. Non-Contact

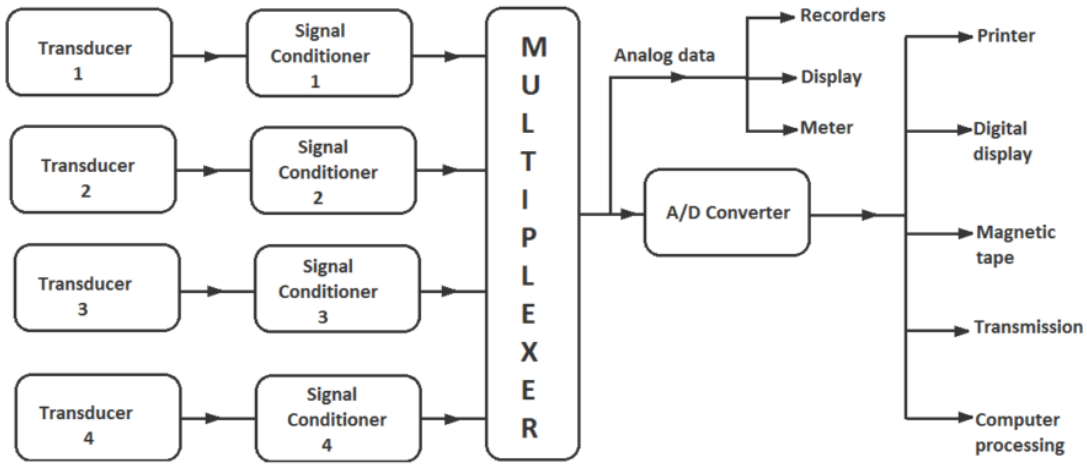
Non-contact tachometers do not need to make any physical contact with a rotating shaft to obtain a measurement.

2. Contact

Contact tachometers have a freely spinning wheel that is brought into direct contact with the rotating shaft to be measured..

Data Acquisition System

A generalized **data acquisition system block diagram** is shown in Figure.



Generalised Data Acquisition System

The function of each block is as under:
Transducers: They are converting physical quantities (such as temperature, pressure, etc.) into electrical quantities, or measuring electrical quantities directly. They collect data from the physical world.

The most commonly used transducers are:

- RTDs, thermocouples, and thermistors for temperature measurements.
- Photosensors for light measurements.
- Strain gages, piezoelectric transducers for force and pressure measurements.
- Microphone for sound measurements.
- Potentiometer, LVDT, optical encoder for position and displacement measurements.

Signal Conditioning Unit: The signal produced by the transducers may or may not be very suitable for our system to work properly. It may be very weak, very strong or may have some noise.
To convert this signal into the most suitable form, amplification, and filtration is done respectively by signal conditioning unit. So the signal conditioning unit converts electrical signals in the most suitable form.

Multiplexer: The multiplexer receives multiple analog inputs and provides a single output signal according to the requirements.

Analog to Digital (A/D) Converters: The data is converted into digital form by A/D converters.

After the conversion of data into digital form, it is displayed with the help of oscilloscopes, numerical displays, panel meters to monitor the complete system.

Also, the data can be either permanently or temporarily stored or recorded according to the requirement. The data is recorded on optical, ultraviolet, stylus or ink recorders for future use.