Faculty:- Deepak Agrawal Model Question Paper

EMI IV sem ECE

Q1. The values of resistance is specified as $100\Omega \pm 5\%$. Find the limits of resistance

Ans. $A = 100\Omega$

Limiting error = 5%

Magnitude of Error $= \frac{5}{100} \times 100 = 5\Omega$

$$A_a = A \pm \delta A = 100 \pm 5\Omega$$

$$= 95\Omega \text{ to } 105\Omega$$

Q2. The length of piece of notebook paper is 27.8 ± 0.1 cm & its width is 21.6 ± 0.1 cm. Find the limiting error in the area.

Ans. Area $= 27.8 \times 21.6$

$= 600.48 \text{ cm}^2$

Fractional error in L & W are

$$e_{length} = \frac{0.1}{27.8} = 0.0036$$

$$e_{width} = \frac{0.1}{21.6} = 0.0046$$

$$e_{area} = e_l + e_w = 0.0036 + 0.0046$$

$$= 0.0082 = 0.82\%$$

$$A_{area} = \text{area} \times e_{area}$$

$$= 600.48 \times 0.0082$$

$$= 4.92 \text{ cm}^2$$

area $= 600.48 \pm 4.92 \text{ cm}^2$

Q3. Write a short note on classification of transducers.

Nearly all engineering applications require some form of measuring, controlling, calculating, communicating and recording of data. These operations, grouped or isolated, are inherent in measurement instrumentation. If the equipment is to be used for the quantitative analysis of an analogue signal, i.e., a naturally occurring signal, the following must be taken into consideration:

The analogue signal to be measured may be **temperature, pressure, humidity, velocity, flow rate, linear motion, position**, amongst others. This signal must be converted into an **analogue electrical signal, typically voltage or current,** and then into a digital form that can be processed by an electronic circuit. The first task (see Fig. 1) requires sensors to convert the **physical quantities into electrical signals**. **Generally, the broad definition of a sensors/ transducers includes devices which convert physical quantities (mechanical force) into analogue electrical signal (in the range of millivolts or milliamps).**

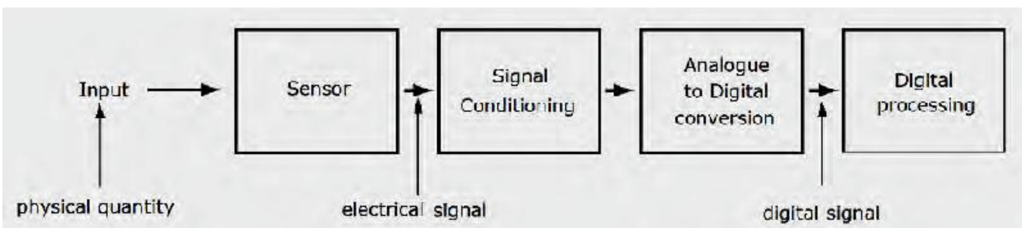


Fig. 1 Data acquisition block diagram

Classification of Transducers

The Classification of Transducers is done in many ways. Some of the criteria for the classification are based on their area of application, Method of energy conversion, Nature of output signal, According to Electrical principles involved, Electrical parameter used, principle of operation, & Typical applications.

The transducers can be classified broadly

i. On the basis of transduction form used

ii. As primary and secondary transducers

iii. As active and passive transducers

iv. As transducers and inverse transducers.

Broadly one such generalization is concerned with energy considerations wherein they are classified as active & Passive transducers.

A component whose output energy is supplied entirely by its input signal (physical quantity under measurement) is commonly called a ‘passive transducer’. In other words the passive transducers derive the power required for transduction from an auxiliary source.

Active transducers are those which do not require an auxiliary power source to produce their output. They are also known as self generating type since they produce their own voltage or current output.

Some of the passive transducers (electrical transducers), their electrical parameter (resistance, capacitance, etc), principle of operation and applications are listed below.

The table 1 & 2 list the principle of operation and applications of the resistance transducers respectively.

The capacitive, inductive, etc transducers are listed next.

Resistance Potentiometric device	Positioning of the slider by an external force varies the resistance in a potentiometer or a bridge circuit.
Resistance strain gage	Resistance of a wire or semiconductor is changed by elongation or compression due to externally applied stress.
Pirani gage or hot-wire meter	Resistance of a heating element is varied by convection cooling of a stream of gas.
Resistance thermometer	Resistance of pure metal wire with a large positive temperature coefficient of resistance varies with temperature.
Thermistor	Resistance of certain metal oxides with negative temperature coefficient of resistance varies with temperature.
Resistance hygrometer	Resistance of a conductive strip changes with moisture content.

Table 1. Type & principle of operation of resistance transducers

Resistance Potentiometric device	Pressure, displacement
Resistance strain gage	Force, torque, displacement
Pirani gage or hot-wire meter	Gas flow, gas pressure
Resistance thermometer	Temperature, radiant heat
Thermistor	Temperature
Resistance hygrometer	Relative humidity
Photoconductive cell	Photosensitive relay

Table 1. Type & applications of resistance transducers

Capacitance Transducers

1. Variable capacitance pressure gage -

Principle of operation: Distance between two parallel plates is varied by an externally applied force

Applications: Measurement of **Displacement, pressure**

2. Capacitor microphone

   Principle of operation: Sound pressure varies the capacitance between a fixed plate and a movable diaphragm. Applications: **Speech, music, noise**

3. Dielectric gage

   Principle of operation: Variation in capacitance by changes in the dielectric. Applications: **Liquid level, thickness**

Inductance Transducers

1. Magnetic circuit transducer

   Principle of operation: Self inductance or mutual inductance of ac-excited coil is varied by changes in the magnetic circuit.

   Applications: **Pressure, displacement**

2. Reluctance pickup

   Principle of operation: Reluctance of the magnetic circuit is varied by changing the position of the iron core of a coil.

   Applications: **Pressure, displacement, vibration, position**

3. Differential transformer

Principle of operation: The differential voltage of two secondary windings of a transformer is varied by positioning the magnetic core through an externally applied force.

Applications: **Pressure, force, displacement, position**

4. Eddy current gage

Principle of operation: Inductance of a coil is varied by the proximity of an eddy current plate.

Applications: **Displacement, thickness**

5. Magnetostriction gage

Principle of operation: Magnetic properties are varied by pressure and stress.

Applications: **Force, pressure, sound**

Voltage and current Transducers

1. Hall effect pickup

Principle of operation: A potential difference is generated across a semiconductor plate (germanium) when magnetic flux interacts with an applied current.

Applications: **Magnetic flux, current**

2. Ionization chamber

Principle of operation: Electron flow induced by ionization of gas due to radioactive radiation. Applications: **Particle counting, radiation**

3. Photoemissive cell

Principle of operation: Electron emission due to incident radiation on photoemissive surface. Applications: **Light and radiation**

4. Photomultiplier tube

Principle of operation: Secondary electron emission due to incident radiation on photosensitive cathode.

Applications: **Light and radiation, photo-sensitive relays**

Self-Generating Transducers (No External Power) – Active Transducers

1. Thermocouple and thermopile

   Principle of operation: An emf is generated across the junction of two dissimilar metals or semiconductors when that junction is heated.

   Applications: **Temperature, heat flow, radiation**

2. Moving-coil generator

   Principle of operation: Motion of a coil in a magnetic field generates a voltage.

   Applications: **Velocity. vibration**

3. **Piezoelectric pickup**

   An emf is generated when an external force is applied to certain crystalline materials, such as quartz

   Sound, vibration. acceleration, pressure changes

4. Photovoltaic cell

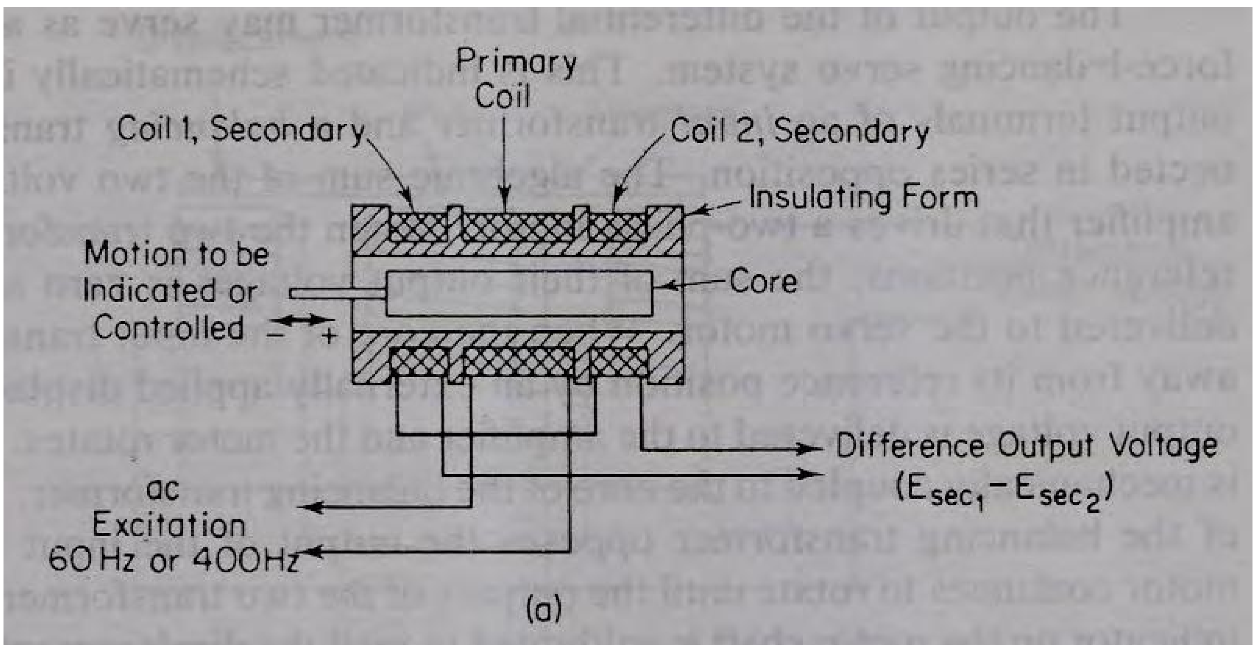
Principle of operation: A voltage is generated in a semi-conductor junction device when radiant energy stimulates the cell

Applications: **Light meter, solar cell**

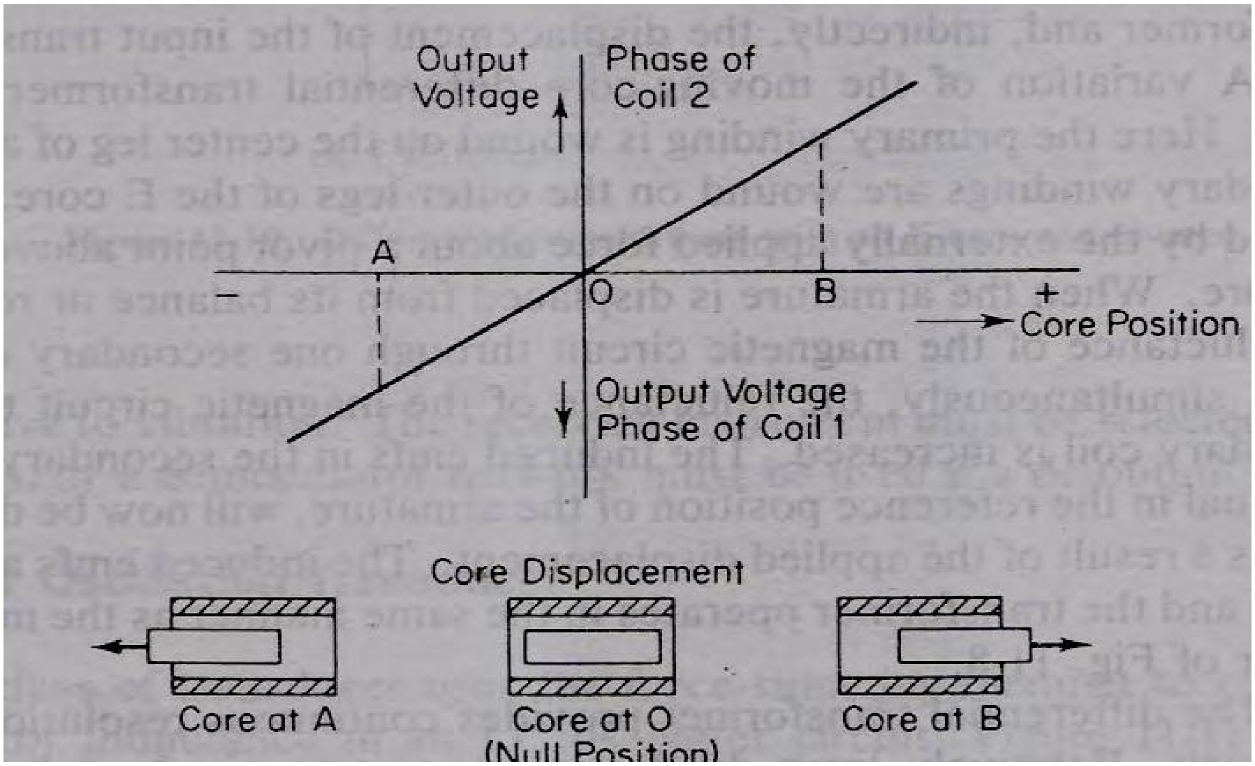
Q4. Explain the construction and working of LVDT

Linear Variable Differential Transformer – LVDT Transducer

The differential transformer transducer measures force in terms of the displacement of the ferromagnetic core of a transformer. The basic construction of the LVDT is given in Fig, 9. The transformer consists of a single primary winding and two secondary windings which are placed on either side of the primary. The secondaries have an equal number of turns but they are connected in series opposition so that the emfs induced in the coils OPPOSE each other. The position of the movable core determines the flux linkage between the ac-excited primary winding and each of the two secondary winding.



Construction of the LVDT



Relative positions of the core generate the indicated output voltages as shown in Fig. 10. The linear characteristics impose limited core movements, which are typically up to 5 mm from the null position.

With the core in the center, (or *reference* position or Fig. 11,), the induced emfs in the secondaries are equal, and since they oppose each other, the output voltage will be 0 V. When an externally applied force moves the core to the left-hand position, more magnetic flux links the left-hand coil than the right-hand coil and the Differential Output E0 = $E_{S1} - E_{S2}$ Is in-phase with Ei as $E_{S1} > E_{S2}$. The induced emf of the left hand coil is therefore larger than the induced emf of the right-hand coil. The magnitude of the output voltage is then equal to the difference between the two secondary voltages, and it is *in phase* with the voltage of the left-hand coil.

Similarly, when the core is forced to move to the right, more flux links the right-hand coil than the left-hand coil and the resultant output voltage is now in phase with the emf of the right-hand coil, while its magnitude again equals the difference between the two induced emfs.

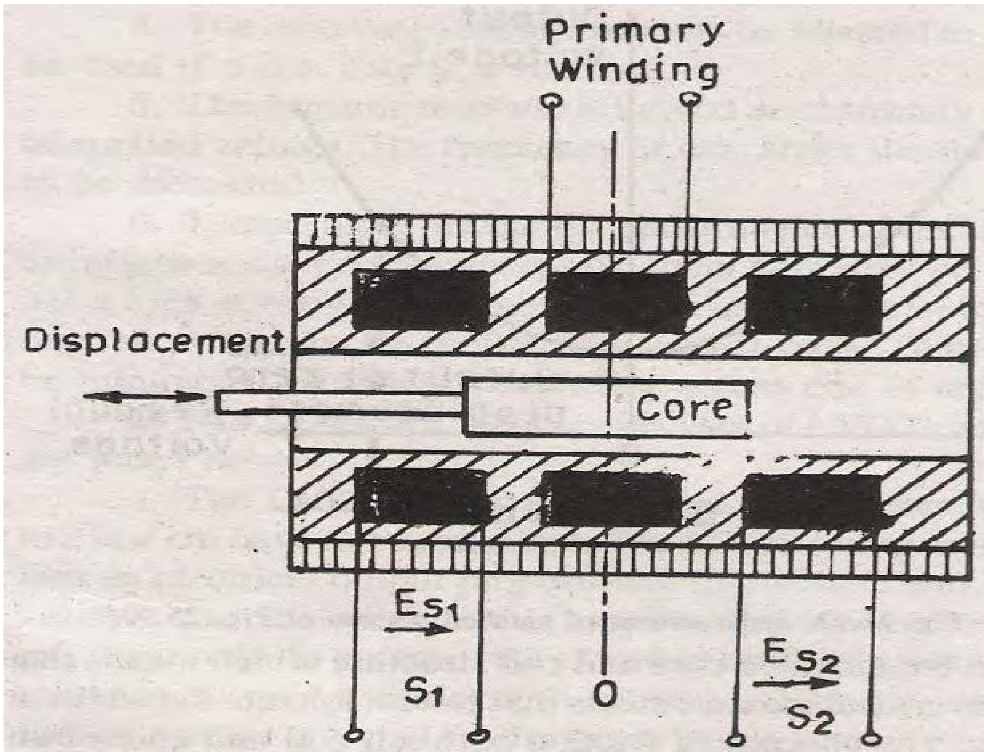


Fig. 11

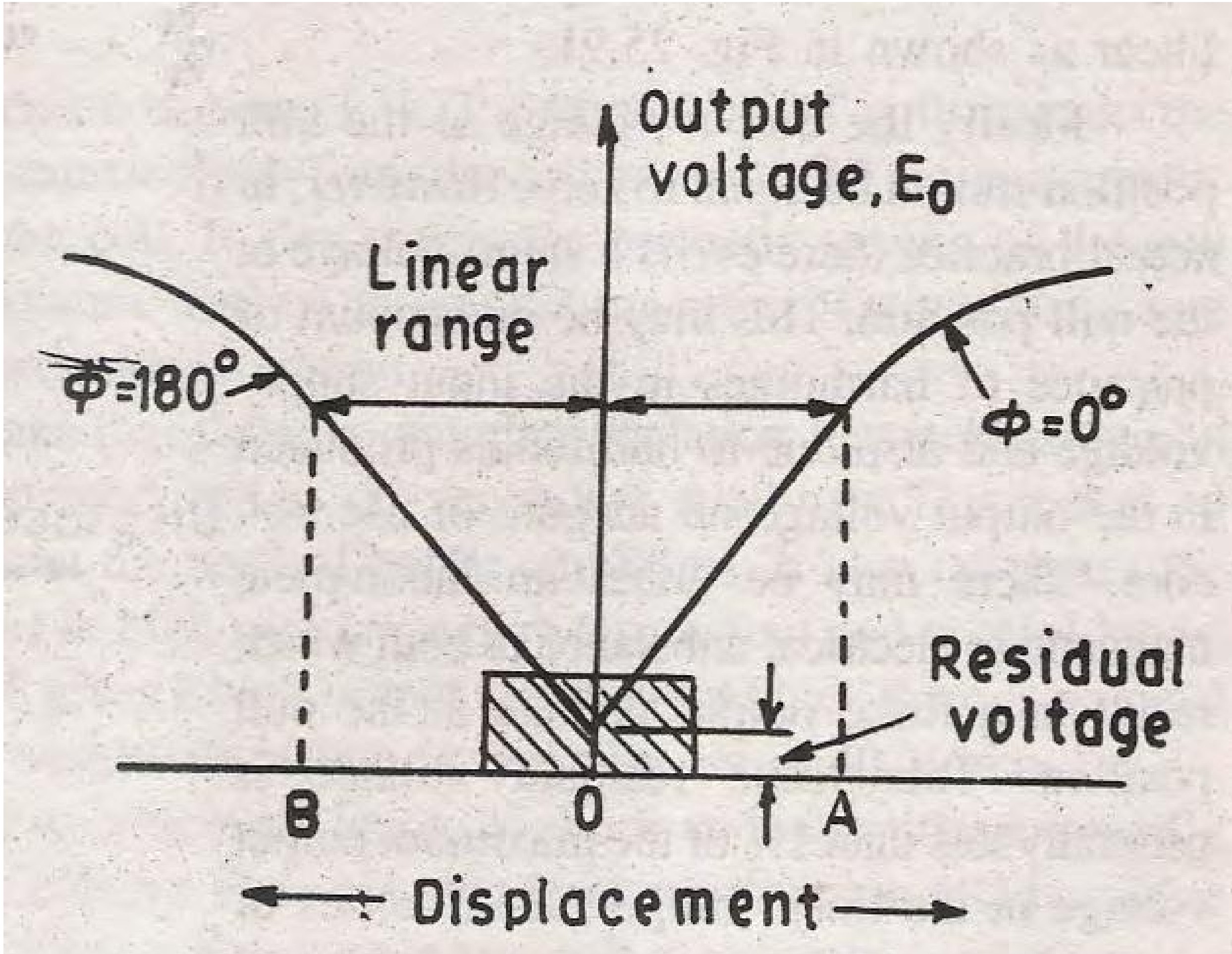


Fig. 12

Ideally the output voltage at the null position should be equal to zero. In actual practice there exists a small voltage at the null position. (refer Fig. 12). This may be on account of **presence of harmonics** in the **input supply voltage** and also due to **harmonics produced in the output voltage** due to use of iron Displacement core. There may be either an **incomplete magnetic or electrical** unbalance or both which result in a finite output voltage at the null position. This finite residual voltage is generally less than 1% of the maximum output voltage in the linear range. Other causes of residual voltage are **stray magnetic fields and temperature effects.**

Applications of LVDT

Acting as a secondary transducer it can be used as a device to measure force, weight and pressure etc. The **force measurement** can be done by using a **load cell** as the **primary transducer** while fluid **pressure** can be measured by using **Bourdon tube** which acts as primary transducer. The force or the pressure is converted into a **voltage**.

In these applications the **high sensitivity** of LVDTs is a major attraction.

Q5.

The output of an LVDT is connected to a 5 V voltmeter through an amplifier whose amplification factor is 250. An output of 2 mV appears across the terminals of LVDT when the core moves through a distance of 0.5 mm. Calculate the sensitivity of the LVDT and that of the whole set up. The milli-voltmeter scale has 100 divisions. The scale can be read to I/5 of a division. Calculate the resolution of the instrument in mm.

Solution:

sensitivity of the LVDT = output voltage / displacement = 2×10^{-3} /0.5

$= 4 \times 10^{-3}$ V/mm = 4mV / mm

sensitivity of the Instrument = amplification factor x sensitivity of LVDT

$= 4 \times 10^{-3} \times 250$ = 1V/mm = 1000 mV/mm

1 scale division = 5/100 V = 50mV

Minimum voltage that can be read on the voltmeter = (1/5) x 50 = 1mV

Resolution of instrument = 1×10^{-3} mm