SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)
Coimbatore-35

DEPARTMENT OF BIOMEDICAL ENGINEERING

23BMT203 - BIOMEDICAL TRANSDUCERS AND SENSORS

UNIT II- Pressure, Displacement and Temperature

II Year/ IV Sem

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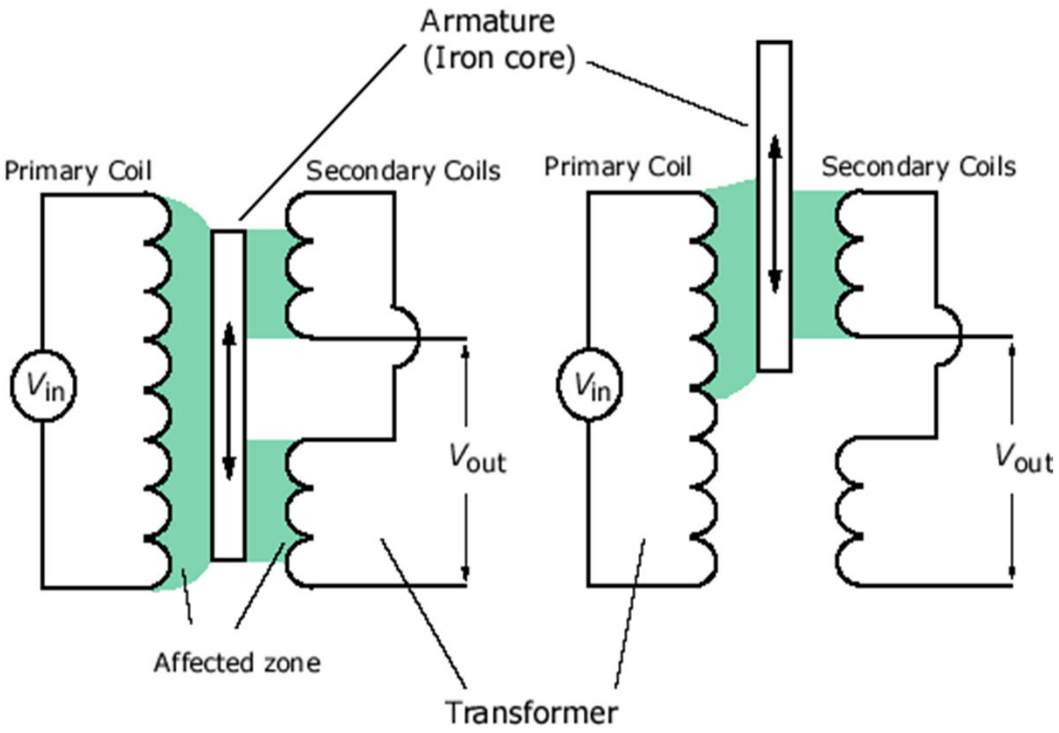
BIOMEDICAL TRANSDUCERS AND SENSORS

- ✓ Resistive Strain Gauges and Bridge circuit
- ✓ Piezoelectric Transducers
- ✓ Potentiometric Transducers
- ✓ Capacitive, Inductive
- ✓ LVDT Transducers - Principle
- ✓ Equivalent Circuit & Linearity Issues
- ✓ Thermo Resistive - Resistance Temperature Detectors (RTDS)
- ✓ Thermistor Thermo Electric - Thermocouple
- ✓ PN Junction Diode

Linear Variable Differential Transformer (LVDT)

Introduction to LVDT

- A **Linear Variable Differential Transformer (LVDT)** is an electromechanical transducer that converts linear displacement (position) into an electrical signal.
- It is widely used in industrial automation, aerospace, robotics, and instrumentation due to its high precision and reliability.



Linear Variable Differential Transformer (LVDT)

Construction of LVDT

Primary Winding (PP):

- A coil wound around the central part of the transformer.
- Excited by an AC voltage (typically 1 kHz to 10 kHz).

Secondary Windings (S1 and S2):

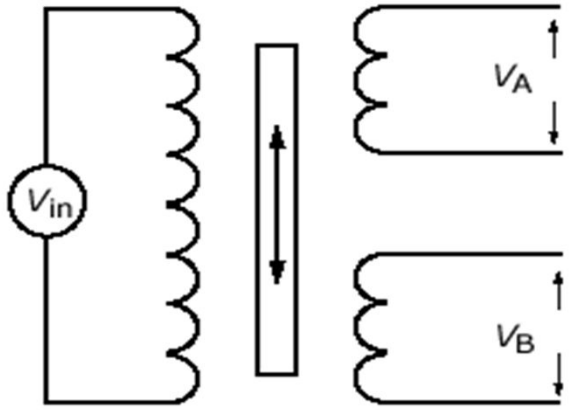
- Two identical coils symmetrically wound on either side of the primary coil.
- Connected in series opposition (differential mode).

Movable Core:

- A ferromagnetic core (usually made of nickel-iron alloy) placed inside the cylindrical coil structure.
- Moves along the axis of the coils in response to displacement.

Non-Magnetic Housing:

- Protects the windings and core while allowing free movement of the core.



Ratiometric Wiring

$$D = M \frac{V_A - V_B}{V_A + V_B}$$

Linear Variable Differential Transformer (LVDT)

Working Principle of LVDT

The LVDT operates based on mutual inductance and the principle of differential transformer action.

Step-by-Step Operation:

1. **Excitation**:
   - An **AC voltage** is applied to the primary coil (PP), generating an alternating magnetic field.
2. **Induced EMF in Secondary Coils**:
   - The alternating magnetic field induces **electromotive forces (EMFs)** in both secondary windings (S1 and S2).
   - The magnitude of induced voltages depends on the position of the core.

Linear Variable Differential Transformer (LVDT)

Three Possible Conditions:

- **Neutral Position (Null Position)**:
  - The core is at the centre.
  - Equal EMFs are induced in S1 and S2, producing equal voltages.
  - Since S1 and S2 are connected in opposite phases, their output cancels out, giving **zero output voltage**.
- **Core Displaced Towards S1**:
  - The EMF in S1 increases while in S2 it decreases.
  - The resultant voltage (Vout=VS1−VS2) is **positive**.
  - Indicates displacement in the **positive direction**.
- **Core Displaced Towards S2**:
  - The EMF in S2S_2 increases while in S1 it decreases.
  - The resultant voltage (Vout=VS2−VS1) is **negative**.
  - Indicates displacement in the **negative direction**.

Linear Variable Differential Transformer (LVDT)

Advantages of LVDT

1. **High Accuracy** – No mechanical friction, leading to precise measurement.
2. **Infinite Resolution** – Theoretically, no limit to the resolution.
3. **High Sensitivity** – Can detect minute displacements.
4. **Frictionless Operation** – No wear and tear as there is no direct contact.
5. **Wide Measurement Range** – Can measure both small and large displacements.
6. **Low Power Consumption** – Works efficiently with minimal power.
7. **Linearity** – Highly linear over a wide range of displacement.
8. **Temperature Stability** – Less affected by temperature variations.

Disadvantages of LVDT

1.Sensitive to Electromagnetic Interference (EMI) – Requires shielding.
2.High Initial Cost – More expensive than simpler sensors.
3.Size Limitations – Large physical size compared to some other displacement sensors.
4.Limited Measurement Range – Large displacements require longer LVDTs.
5.Excitation Source Required – Needs an AC supply.

Linear Variable Differential Transformer (LVDT)

Applications of LVDT

Industrial & Automation

- Position control in CNC machines.
- Robotic arm displacement measurement.
- Valve position monitoring in process industries.

Aerospace & Defense

- Aircraft control surface displacement measurement.
- Missile guidance system position sensing.

Medical Applications

- Precise motion control in prosthetics.
- Medical imaging equipment motion sensing.

Structural Monitoring

- Bridge expansion monitoring.
- Railway track displacement measurement.

Automotive Industry

- Suspension system testing.
- Engine throttle position sensing.

Characteristics of LVDT

1. **Range**: Typically ranges from ±0.25 mm to ±500 mm.
2. **Excitation Frequency**: Usually between **1 kHz to 10 kHz**.
3. **Linearity**: ±0.05% to ±0.5% of full scale.
4. **Temperature Coefficient**: Small drift with temperature changes.