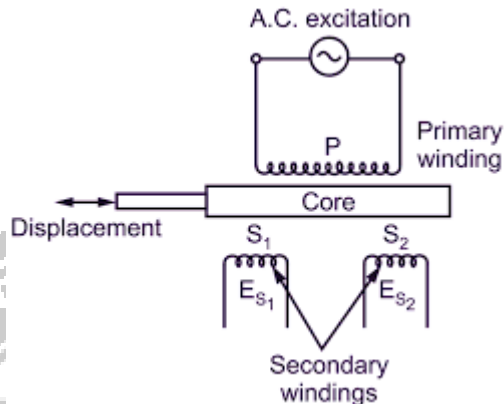


2.3 Linear Variable Differential Transformer (LVDT)



Introduction

- An LVDT is an electromechanical transducer that converts linear displacement into an electrical signal.
- Widely used for precise measurement of linear position.

Construction

- **Core:** A cylindrical ferromagnetic core that moves linearly.
- **Primary Coil:** One coil located at the center, excited by an AC voltage.
- **Secondary Coils:** Two identical coils placed symmetrically on either side of the primary coil, connected in series but with opposite polarity.

Working Principle

1. **Excitation:** The primary coil is energized with an AC voltage, creating an alternating magnetic field.
2. **Induction:** This magnetic field induces voltages in the secondary coils.
3. **Core Position:**
 - **Central Position:** When the core is centered, the voltages induced in the two secondary coils are equal and opposite, resulting in a net output voltage of zero.
 - **Displaced Position:** When the core moves from the center, it changes the magnetic coupling, causing an imbalance in the induced voltages, which results in a differential voltage proportional to the displacement.

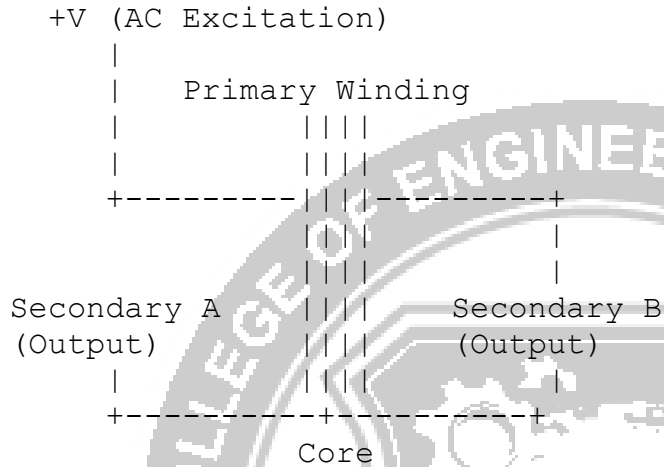
Working Phases

- **Null Position:** Core is at the center, $V_{out} = 0V$.
- **Positive Displacement:** Core moves toward one end, V_{out} increases proportionally.
- **Negative Displacement:** Core moves toward the opposite end, V_{out} decreases proportionally.

Circuit Diagram

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Output Characteristics

- **Linearity:** The output voltage is linearly proportional to the displacement over a specified range.
- **Sensitivity:** The change in output voltage per unit change in displacement, typically expressed in mV/mm.
- **Range:** The maximum linear displacement that the LVDT can accurately measure.

Advantages

- High accuracy and resolution.
- Frictionless operation, leading to long life and reliability.
- Robust and capable of operating in harsh environments.
- Infinite resolution and repeatability.

Applications

- **Industrial Automation:** Position feedback for hydraulic cylinders and actuators.
- **Aerospace:** Measurement of control surface positions.
- **Robotics:** Precise measurement of linear movements.
- **Automotive:** Suspension system monitoring and testing.
- **Medical Devices:** Measurement in diagnostic equipment and patient positioning systems.

Error Sources

- **Mechanical Misalignment:** Can cause nonlinear output or erroneous readings.
- **Temperature Variations:** Affect the core and coil properties, potentially leading to drift in output.
- **Electromagnetic Interference (EMI):** Can introduce noise and affect the accuracy.

Error Analysis

- **Mechanical Precision:** Ensure precise alignment and rigid mounting to minimize mechanical errors.
- **Temperature Compensation:** Implement temperature compensation techniques or use materials with low thermal sensitivity.
- **Shielding and Filtering:** Use proper shielding and filtering techniques to reduce the impact of EMI.

Maintenance and Calibration

- Regular calibration to maintain accuracy.
- Periodic inspection for mechanical wear and alignment issues.
- Ensure proper environmental protection to avoid contamination and damage.

Summary

An LVDT is a highly precise and reliable device for measuring linear displacement in various applications. Understanding its construction, working principles, and potential error sources is crucial for accurate measurement and application.

