

2.2 Potentiometers

Introduction

- A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider.
- Commonly used for adjusting levels, such as volume control in audio equipment.

Types of Potentiometers

1. **Rotary Potentiometer:** Has a knob that rotates to adjust resistance.
2. **Linear Potentiometer:** Has a slider that moves linearly to adjust resistance.
3. **Digital Potentiometer:** Adjusts resistance electronically, often controlled by microcontrollers.

Construction

- **Resistive Element:** A strip of resistive material (carbon, cermet, wire).
- **Wiper:** A movable contact that slides over the resistive element.
- **Terminals:** Three terminals: two connected to the ends of the resistive element, and one connected to the wiper.

Working Principle

- The potentiometer divides the input voltage based on the position of the wiper.
- The voltage at the wiper (output) is a fraction of the total voltage applied across the end terminals.
- The position of the wiper determines the resistance between the wiper and the end terminals, thus varying the output voltage.

Circuit Diagram

```
plaintext
Copy code
+V (Input Voltage)
|
R1
|-----> Wiper (Output Voltage)
R2
|
Ground
```

Where R1 and R2 are variable resistances determined by the position of the wiper.

Applications

- **Volume Control:** Adjusting audio levels in radios and amplifiers.
- **Position Sensing:** In joysticks, servos, and other control devices.

- **Adjustable Power Supplies:** Setting voltage or current levels.
- **Calibration:** Fine-tuning circuits in test and measurement equipment.

Advantages

- Simple and easy to use.
- Provides continuous adjustment.
- Available in a wide range of sizes and resistance values.

Disadvantages

- Mechanical wear over time.
- Limited resolution compared to digital counterparts.
- Potential noise due to wiper movement.

Error Sources

- **Mechanical Wear:** Leads to inaccuracy and noise over time.
- **Temperature Variations:** Can affect the resistance value and stability.
- **Contact Resistance:** Variable contact resistance can introduce noise and non-linearity.

Error Analysis

- **Mechanical Precision:** High-quality materials and construction reduce wear and improve lifespan.
- **Temperature Compensation:** Use materials with low temperature coefficients.
- **Regular Maintenance:** Periodically clean and inspect potentiometers to ensure accuracy.

Maintenance and Calibration

- Regular inspection for mechanical wear and cleanliness.
- Periodic calibration to ensure accurate output.
- Replace worn or damaged potentiometers to maintain performance.

Summary

Potentiometers are versatile components used for variable resistance and voltage division in a variety of applications. Understanding their construction, working principles, and potential error sources is essential for effective usage and maintenance.