SNJB's

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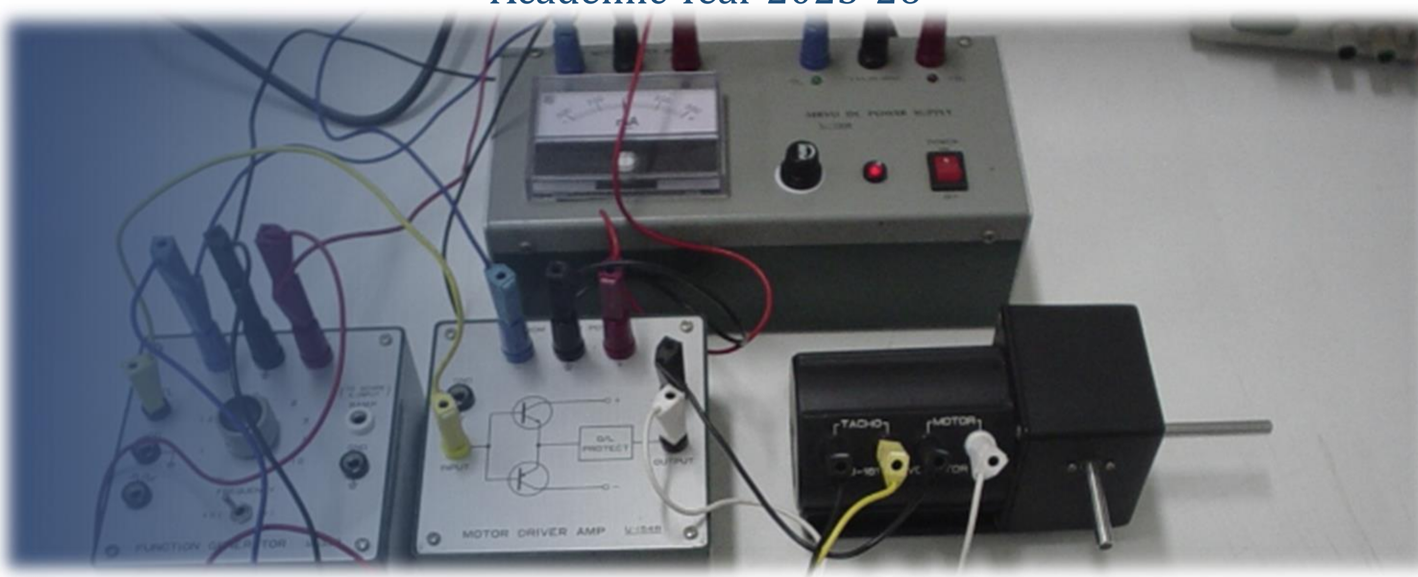

by

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Wheatstone Bridge and Its Applications in Strain Gauge Measurement

Topics to be discussed:

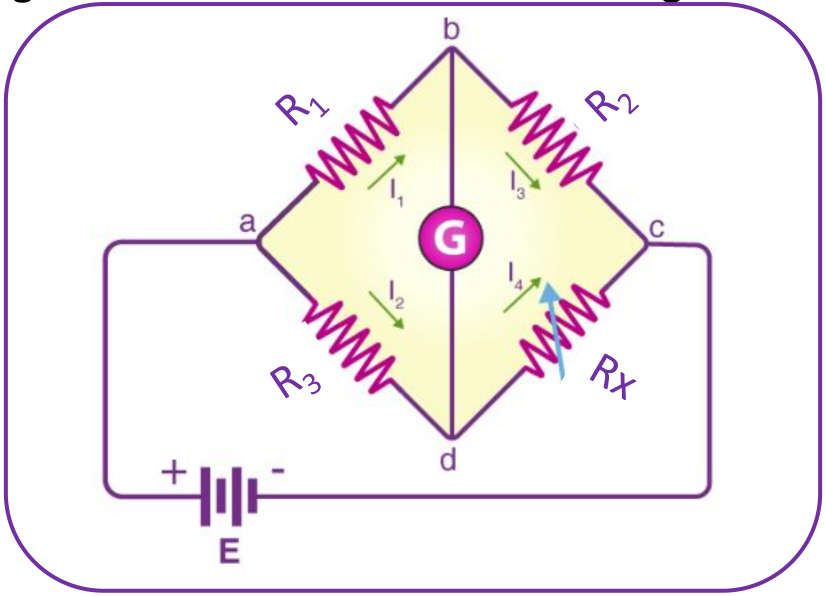
1. What is a Wheatstone bridge?
2. Its Working principle
3. Applications of whetstone bridge
4. Measuring unknown resistance with balanced condition- with example
5. Wheatstone bridge with Strain gauge- with example

What is a Wheatstone bridge?

A **Wheatstone Bridge** is an electrical circuit used to **precisely measure an unknown resistance** by balancing two legs of a bridge circuit. It is widely used in sensors (like strain gauges) and precision measurement instruments.

Basic Structure:

The Wheatstone Bridge consists of **four resistors** arranged in a diamond shape:

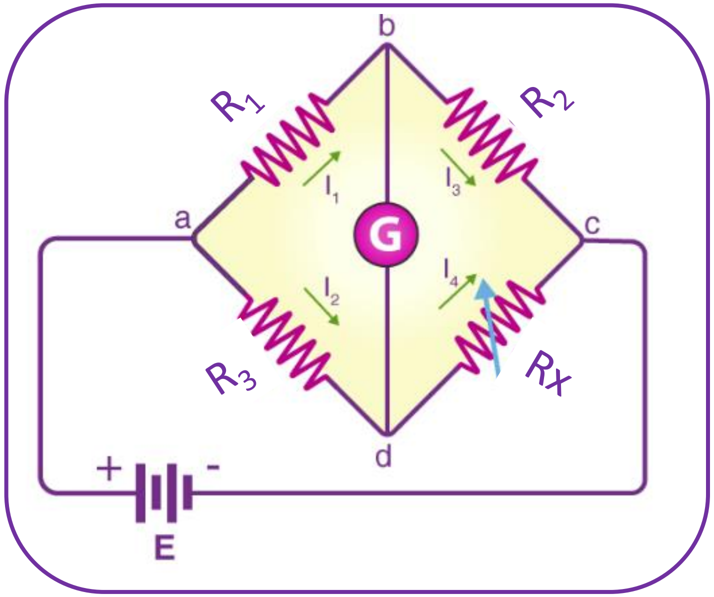


- **Rx** is the unknown resistor.
- A voltage source is applied between points **A and C**.
- A **galvanometer** (G) is connected between **points B and D**.
- **R1, R2, R3** are known resistors.

Working Principle:

- When the bridge is **balanced**, no current flows through the galvanometer (**G = 0**).
- The balance condition is:

$$\frac{R1}{R2} = \frac{R3}{Rx}$$



From this, the unknown resistance Rx can be calculated as:

$$Rx = \frac{R3 \times R2}{R1}$$

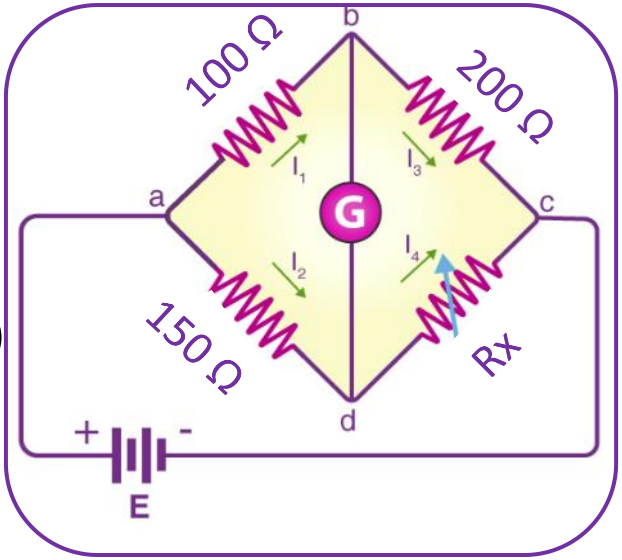
Applications:

- Measuring small changes in resistance.
- Used in **strain gauges** to measure stress or pressure.
- Temperature sensors (like RTDs).
- Calibration and testing equipment.

Let's walk through a **practical example** of how the **Wheatstone Bridge** works with real resistor values. We'll do two things:

1. **Solve for an unknown resistance (Rx)** when the bridge is balanced.
2. Then show how it's used in a **strain gauge application**.

Example 1: Measuring an Unknown Resistance (Balanced Bridge)



Given:

- $R_1 = 100\ \Omega$
- $R_2 = 200\ \Omega$
- $R_3 = 150\ \Omega$
- Rx = unknown
- Galvanometer shows **zero current** (balanced bridge)

Use the balance condition:

$$\frac{R1}{R2} = \frac{R3}{Rx}$$

$$\frac{100}{200} = \frac{150}{Rx}$$

$$\frac{1}{2} = \frac{150}{Rx} \Rightarrow Rx = 300\ \Omega$$

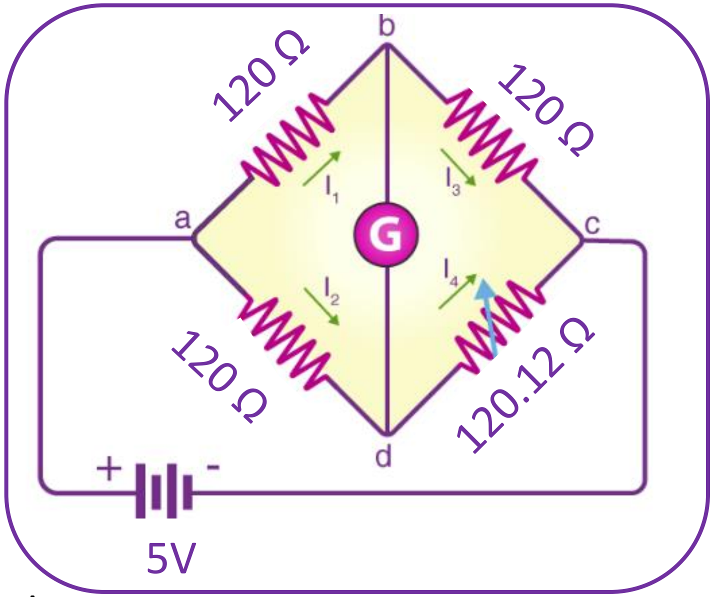
So, the unknown resistance Rx= 300 Ω

Example 2: Wheatstone Bridge with a Strain Gauge

Let's say we're using a strain gauge with resistance **R = 120 Ω**, and it increases slightly due to mechanical strain.

Bridge setup:

- R_1 = 120 Ω
- R_2 = 120 Ω
- R_3 = 120 Ω
- Rx = 120.12 Ω (slightly increased due to strain)
- Supply voltage = 5V



Goal: Measure **output voltage (V_{out})** between B and D

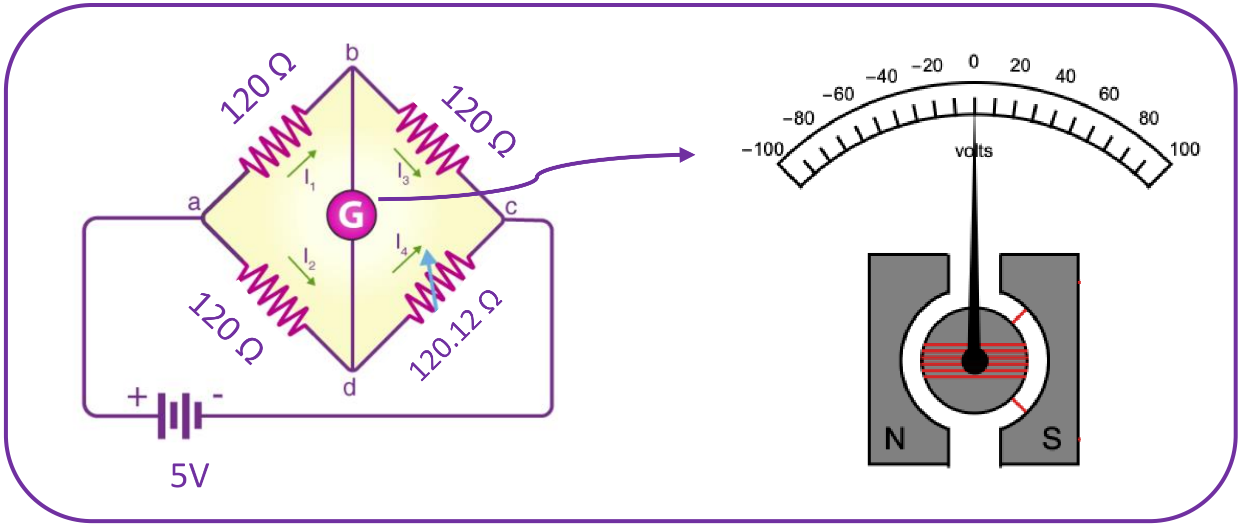
Use the **output voltage formula** for an unbalanced bridge:

$$V_{\text{out}} = V_s \times \left(\frac{R2}{R1 + R2} - \frac{Rx}{R3 + Rx} \right)$$

Substituting the values:

$$V_{\text{out}} = 5 \times \left(\frac{120}{120 + 120} - \frac{120.12}{120 + 120.12} \right)$$

$$V_{\text{out}} = 5 \times \left(0.5 - \frac{120.12}{240.12} \right) \approx 5 \times (0.5 - 0.50025) = 5 \times (-0.00025) = -0.00125\ V$$



So the output is **-1.25 mV**, which can be amplified and measured to detect the strain.

- Wheatstone bridge is **very sensitive** to small resistance changes.
- Useful for **precision sensors** like strain gauges, pressure sensors, and temperature probes.

Thank You!