Understanding Wheatstone Bridge Principle

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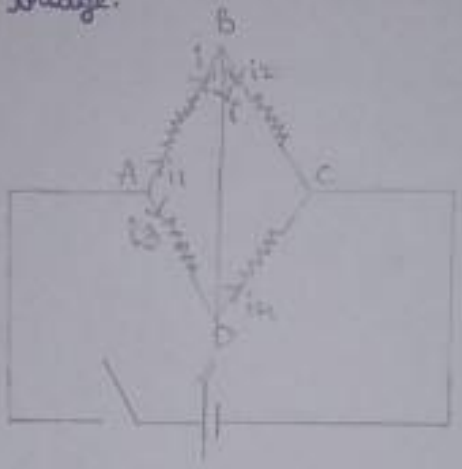
Wheat Stone Bridge :-

A "Wheatstone Bridge" is an electrical circuit used to measure an unknown electrical resistance.

The Wheatstone Bridge was invented by "Samuel Hunter Christie" in 1833 and improved and popularized by Sir "Charles Wheatstone" in 1843.

"Galvanometer" is used to detect when the Bridge circuit is balanced by sensing the current flowing through it in a Wheatstone Bridge.



In WSB since current i through R has to be zero

As per Ohm's law $i = \frac{V_B - V_D}{R} = 0$ - ①

This is possible only when

ⓐ Either $V_B - V_D = 0$

ⓑ or $R \to \infty$

Since R is finite

∴ only possibility is $V_B - V_D = 0$

$V_B = V_D$ - ②

As per "Kirchoffs Current law",

at node B $i_4 = i + i_2$

In wheatstone bridge $i = 0$

$$i_1 = i_2 \quad - (3)$$

At node D $i_3 + i = i_4$

Since $i = 0$

$$i_3 = i_4 \quad - (4)$$

$V_B = V_A - i_1 \times R_1$ - Voltage equation for A B

$$i_1 = \frac{V_A - V_B}{R_1} \quad - (5)$$

$$i_2 = \frac{V_A - V_D}{R_2} \quad - (6)$$

$$i_1 = \frac{V_B - V_C}{R_3} \quad - (7)$$

$$i_2 = \frac{V_D - V_C}{R_4} \quad - (8)$$

From equations (5) and (7)

$$\frac{V_A - V_B}{R_1} = \frac{V_B - V_C}{R_3}$$

From equations (6) and (8)

$$\frac{V_A - V_D}{R_2} = \frac{V_D - V_C}{R_4} \quad -(9)$$

$$\frac{R_1}{R_3} = \frac{V_A - V_B}{V_B - V_C} \quad -(10) \qquad \frac{R_2}{R_4} = \frac{V_A - V_D}{V_D - V_C} \quad -(11)$$

For $i = 0$, $\frac{V_B - V_D}{R} \Rightarrow V_B - V_D = 0$ [or] $V_B = V_D$

Rewrite equation (10) by substituting $V_B = V_D$

$$\frac{R_1}{R_3} = \frac{V_A - V_D}{V_D - V_C} \quad -(12)$$

Rewrite (11) $\frac{R_2}{R_4} = \frac{V_A - V_D}{V_D - V_C}$ $-(13)$

Combining (12) and (13)

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \text{ or } \frac{R_1}{R_3} = \frac{R_2}{R_4} \quad -(14)$$

Therefore any value of R $0 \leq R < \infty$