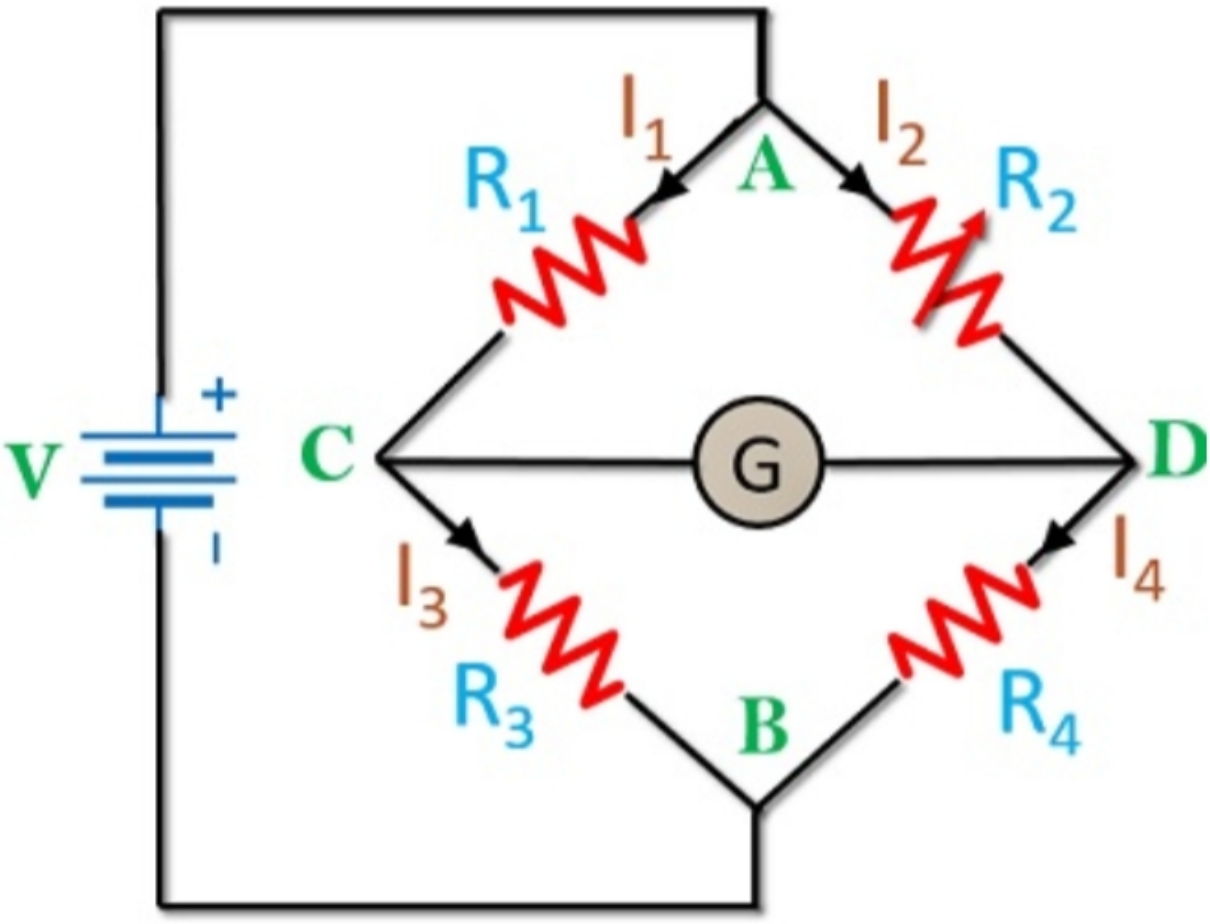
Wheatstone Bridge

Definition: Wheatstone bridge is a type of **dc bridge that is used for the measurement of unknown resistance**. It is a series-parallel combination of 4 resistances that provides zero difference voltage at the balanced condition. The principle of **null indication** is the basis of working of Wheatstone bridge and thus provides high accuracy in measurements.

Circuit construction and theory of Wheatstone bridge

The figure below shows the general circuit of the Wheatstone bridge. It consists of 4 arms namely AC, AD, BC and BD each containing resistance R_1, R_2, R_3 and R_4. Here, R_2 is the variable resistance and R_4 is the unknown resistance.



Wheatstone bridge circuit

It consists of four resistances, out of which 2 are known resistances, one is variable resistance that is used to balance the bridge and another one is unknown resistance whose value is to be measured.

Under the balanced condition, the ratio of the values of two known resistances becomes equivalent to the ratio of the variable resistance and the unknown resistance value. Thus, allows us to **calculate the unknown value** of the resistance employed in the electrical circuit.

A galvanometer is placed at one arm which detects the flow of current through the circuit on providing the supply voltage at another arm of the circuit.

Let us see how unknown resistance can be calculated in balanced condition of a Wheatstone bridge.

In the absence of any current through the galvanometer, the bridge gets balanced. In other words, the bridge gets balanced when the voltage difference between the two points C and D are equal. Thus, providing 0 voltage across the galvanometer.

In order to determine the bridge balance equation,

$$I_1 R_1 = I_2 R_2$$

The following condition must be fulfilled in order to have null current through the galvanometer.

$$I_1 = I_3 = \frac{V}{R_1 + R_3}$$

$$I_2 = I_4 = \frac{V}{R_2 + R_4}$$

On substituting the above value in previously defined equation

$$\frac{V\ X\ R_1}{R_1+R_3} = \frac{V\ X\ R_2}{R_2+R_4}$$

$$R_1X\ (R_2 + R_4) = R_2X\ (R_1 + R_3)$$

$$R_1R_2 + R_1R_4 = R_2R_1 + R_2R_3$$

Thus, on cancelling like terms from both the sides, we will have,

$$R_4 = \frac{R_2 R_3}{R_1}$$

Hence, we can determine the value of **unknown resistance in balanced condition** using known resistances.

Applications of Wheatstone bridge

- It is used to measure dc resistance.
- Wheatstone bridge is widely used in cable faults identification by telephone companies.
- It can measure physical quantities like light, temperature etc when used with an op-amp.
- By some modulation to bridge network, we can calculate capacitance, inductance and impedance.

Limitations of Wheatstone bridge

- In Wheatstone bridge sometimes measurements of low resistance generate erroneous results. Thus, Kelvin's double bridge was introduced to overcome this.
- It is always preferable to measure medium resistances with Wheatstone bridge as for high resistance measurements it is not suitable. This is so because in case of high resistance the galvanometer is not sensitive to imbalance.
- The heating effect due to the current in the circuit unnecessarily changes the resistances employed in it. This sometimes causes a permanent change in resistance due to a large current in the circuit.