# Measurement of Medium Resistance (1Ω – 100kΩ)

Following are the methods employed for measuring a resistance whose value is in the range 1Ω – 100kΩ –

- Ammeter-Voltmeter Method
- Wheatstone Bridge Method
- Substitution Method
- Carey- Foster Bridge Method
- Ohmmeter Method

## Ammeter Voltmeter Method

This is the most crude and simplest method of measuring resistance. It uses one ammeter to measure current, I and one voltmeter to measure voltage, V and we get the value of resistance as

$$R = \frac{V}{I}$$

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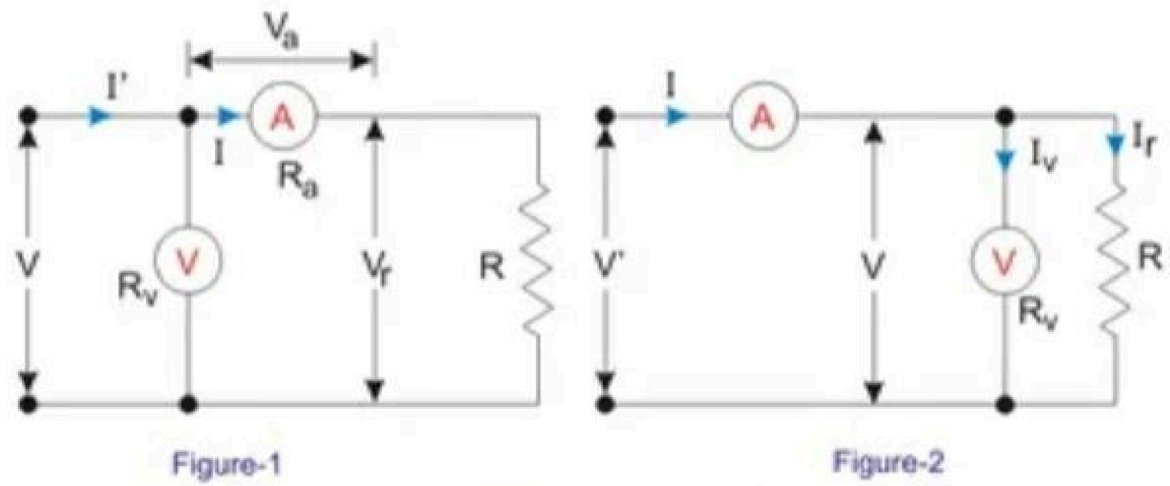
Now we can have two possible connections of ammeter and voltmeter, shown in the figure below.




Ammeter Voltmeter Method

Now in figure 1, the voltmeter measures voltage drop across ammeter and the unknown resistance, hence

$$R_1 = \frac{(V_a + V_r)}{I} = \frac{(IR_a + IR)}{I} = R_a + R$$

Hence, the relative error will be,

$$\epsilon = \frac{R_1 - R}{R} = \frac{R_a}{R}$$

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For connection in figure 2, the ammeter measures the sum of current through voltmeter and resistance, hence

$$R_2 = \frac{V}{(I_v + I_r)} = \frac{V}{\left(\frac{V}{R_v} + \frac{V}{R}\right)} = \frac{R}{\left(1 + \frac{R}{R_v}\right)}$$

The relative error will be,

$$\epsilon = \frac{R_2 - R}{R} \approx -\frac{R}{R_v}$$

It can be observed that the relative error is zero for $R_a = 0$ in first case and $R_v = \infty$ in second case. Now the questions stand that which connection to be used in which case. To find out this we equate both the errors

$$\frac{R_a}{R} = \frac{R}{R_v} \; or \; R = \sqrt{R_a R_v}$$

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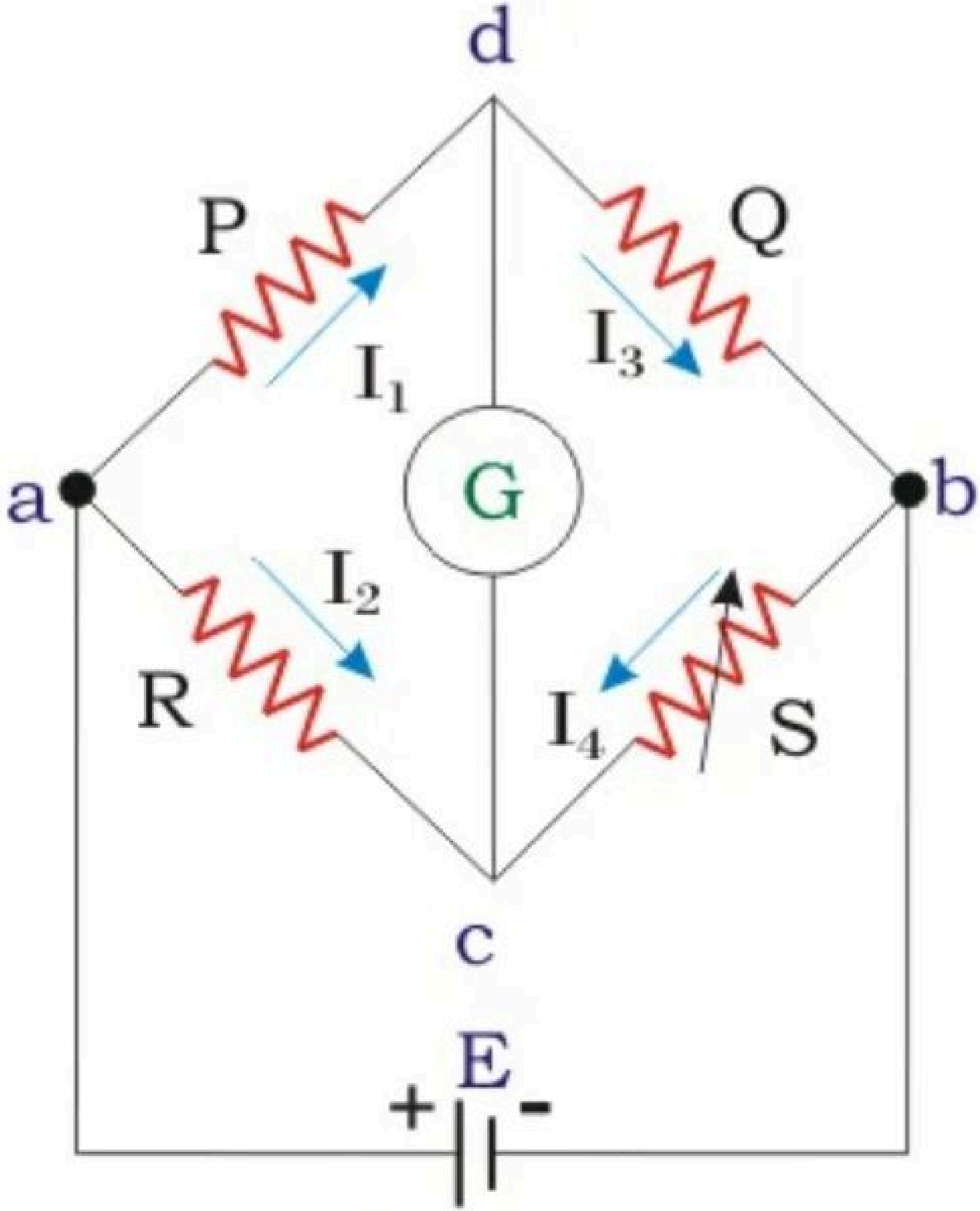
Hence for resistances greater than that given by above equation we use the first method and for less than that we use second method.

## Wheatstone Bridge Method

This is the simplest and the most basic bridge circuit used in measurement studies. It mainly consists of four arms of resistance P, Q; R and S. R is the unknown resistance under experiment, while S is a standard resistance. P and Q are known as the ratio arms. An EMF source is connected between points a and b while a galvanometer is connected between points c and d.



Wheatstone Bridge

A bridge circuit always works on the principle of null detection, i.e. we vary a parameter until the detector shows zero and then use a mathematical relation to determine the unknown in terms of varying parameter and other constants. Here also the standard resistance, S is varied in order to obtain null deflection in the galvanometer. This null deflection implies no current from point c to d, which implies that potential of point c and d is same. Hence

$$I_1P = I_2R \ldots\ldots(4)$$

$$Also,\ I_1 = I_3 = \frac{E}{(P+Q)}\ and\ I_2 = I_4 = \frac{E}{(R+S)}\ \ldots\ldots(5)$$

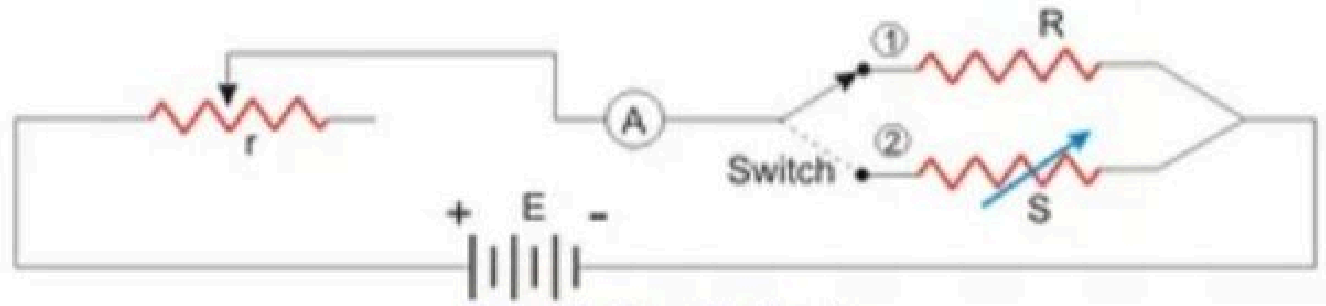
Combining the above two equations we get the famous equation –

$$R = \frac{P}{Q}S$$

## Substitution Method



The figure below shows the circuit diagram for resistance measurement of an unknown resistance R. S is a standard variable resistance and r is a regulating resistance.




Substitution Method

First the switch is place at position 1 and the ammeter is made to read a certain amount of current by varying r. The value of ammeter reading is noted. Now the switch is moved to position 2 and S is varied in order to achieve the same ammeter reading as it read in the initial case. The value of S for which ammeter reads same as in position 1, is the value of unknown resistance R, provided the EMF source has constant value throughout the experiment.