Measurement of Resistance

The resistance is classified only for the purpose of measurements

(i) Low resistance ($< 1\Omega$), armature wdg resi, Series field wdg, Compensal wdg resi

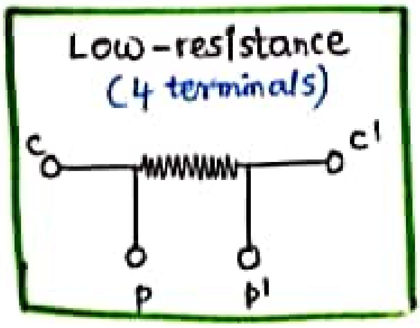
(ii) Medium resistance ($1 - 100\,k\Omega$) (or) ($1 - 0.1\,M\Omega$)

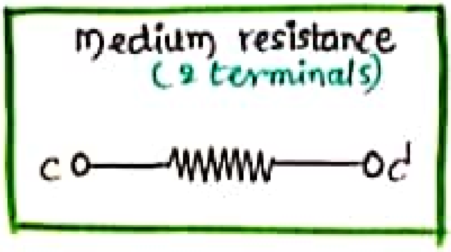
(iii) High resistance ($> 100\,k\Omega$)

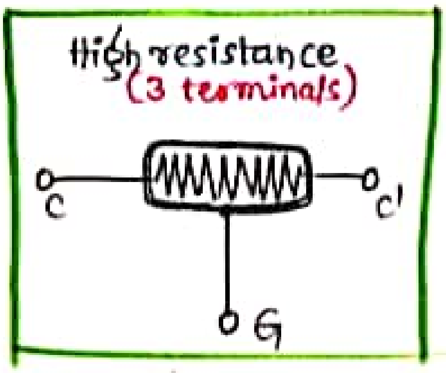
→ ammeter shunt resistance, diode forward bias resistance, link resistance (Lead "). Slide wire resistance.

→ Shunt field wdg resistance, resistance of heating elements (heaters) All electrical appliance equipment resistors in domestic purposes. (daily life).

→ Insulation resistance of underground cable, insulators (power system). Insulation resistance of dielectrics, power diode – reverse bias resistance Series multiplier resistance of voltmeter, input resistance of CRO. I/p resistance Op-Amp, FETs ... etc.







G (Guard terminal).

CC' – current terminals

PP' – voltage/potential "

$$R = \frac{V_{PP'}}{I_{CC'}}$$

4 probe Method.

Errors :– (Difficulties)

1. Due to contacts
2. Due to leads
3. Due temperature change
4. Due to thermal emf

Difficulties faced in measurement of high resi (or) Errors :–

1. Error due to leakage currents (these can be carried by using guard wire)
2. Error due to Specimen capacitance.
3. i.e. Error due to electro-static field effect

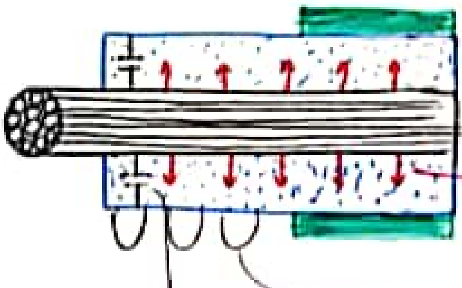


Fig: Underground power cable cross-sectional view pertaining to difficulties of high resistance measurement.

Low resistance can be measured by

(i) Ⓐ – Ⓥ method

(ii) potentiometer

(iii) Kelvin double bridge → most accurate ($R \Rightarrow 0.1\mu\Omega$ to 1Ω).

✓(iv) All above..

Measurements can be measured by (meadium)

(i) Ⓥ - Ⓐ method

(ii) Substitution method

(iii) Ohmmeter → Series type.
→ Shunt type.

(iv) wheatstone Bridge. → accurate more

High-resistance measured by

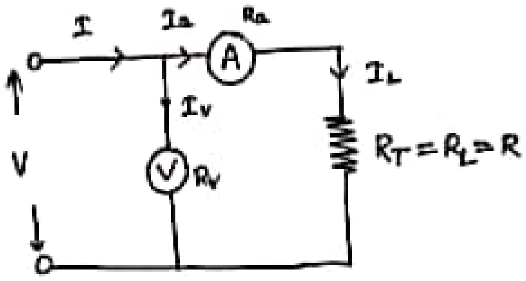
(i) Loss of charge

(ii) Direct deflection method

(iii) Megger Device

(iv) Mega-ohm Bridge method. → most accurate.

Voltmeter- Ammeter Method :-



$I_a = I_L$

$$R_{measured} = R_m = \frac{V}{A} = \frac{V_{supply}}{I_a}$$

$$= \frac{I_a R_a + I_L R_L}{I_a}$$

$$R_m = (R_a + R_L)$$

$$R_m = R_T + R_a$$

$$Error = (A_m - A_T) = R_m - R_T = R_a$$

$\therefore$ Error = +ve ; $\Rightarrow$ (measured) > (true value) $\therefore R_m > R_T$.

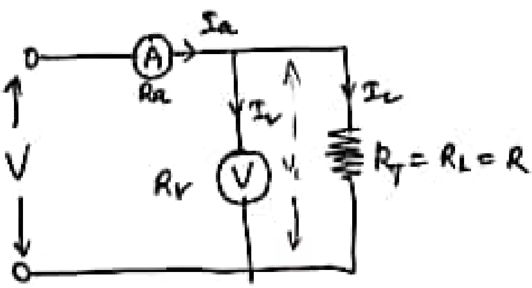
$$\% \, Error = \frac{R_m - R_T}{R_T} \times 100 = \frac{R_a}{R_T} \times 100$$

Ideally $\Rightarrow$ if we try $(R_a \rightarrow 0\,\Omega)$

Note :- voltmeter-ammeter is best suitable for measurement of large value of resistance in a medium resistance range.

The produced error is positive b/c of ammeter connected on load side. Ideally ammeter resistance is zero but practically it is never possible, it is only known as loading effect of ammeter.

Ammeter-voltmeter Method :-



$$R_m = \frac{V}{A} = \frac{I_L R_L}{I_a} = \frac{V_L}{I_a}$$

$$= \frac{I_L R_L}{I_L + I_V} = \frac{V_L}{\frac{V_L}{R_L} + \frac{V_L}{R_V}}$$

$$R_m = \frac{R_L R_V}{R_L + R_V}$$

$\frac{1}{R_m} = \frac{1}{R_L} + \frac{1}{R_V}$

$$R_m = \frac{R_L R_V}{R_V\left(1+\frac{R_L}{R_V}\right)} \Rightarrow R_m = \frac{R_L}{\left(1+\frac{R_L}{R_V}\right)}$$

$$R_m = R_L\left(1+\frac{R_L}{R_V}\right)^{-1}$$

$$R_m = R_L\left(1 - \frac{R_L}{R_V} + \left(\frac{R_L}{R_V}\right)^2 - \frac{R_L^3}{R_V^3} + \dots\right)$$

$$R_m \cong R_L\left(1 - \frac{R_L}{R_V}\right)$$

$$\therefore R_m = R_L - \frac{R_L^2}{R_V}$$

$$\text{Error} = R_m - R_T = -\frac{R_L^2}{R_V}$$

Error = -ve ⇒ (measured) < (true value)

$$\therefore \%\,\text{Error} = \frac{R_m - R_T}{R_T} \times 100 = \frac{-R_T}{R_V} \times 100. \quad (\because R_L = R_T = R)$$

ideally $R_V \Rightarrow \infty\Omega$ (error → 0). never possible.

Note:- ① Ammeter-voltmeter method is best suitable for measurement of load resistances, the produced error is negative, error is because of voltmeter connected on Load side.

Ideally voltmeter resistance is ∞, practically it is not possible

it is only known as Loading Effect of voltmeter.

② To get same error in both the methods

$$\%\,\text{error}_{Ⓐ-Ⓥ} = \%\,\text{error}_{Ⓥ-Ⓐ}$$

$$\left|\frac{-R_L}{R_V}\right| = \left|\frac{+R_a}{R_L}\right|$$

$$\therefore R_L^2 = R_a R_V \Rightarrow \boxed{R_L = \sqrt{R_a R_V}}$$