# Ground Resistance Testing - P2

STUDY FOR FE

**IEEE® Standards on Grounding**

- IEEE® Standard 80 - Concerned with grounding of outdoor AC substations
- IEEE® Standard 81 - Concerned with measurement of soil resistivity and grounding resistance of installed systems
- IEEE® Standard 142 (Green Book) - Concerned with design and practical aspects of grounding

**Ground resistance testing methods**

- Equally spaced 4-pin Method / Wenner Array: Wenner 4-pin method is the most commonly used ground resistance measuring technique.
  - **Procedure**
    - 4 electrodes of equal length 'l' are driven in a straight line at equal distance 'a'
    - Voltage between inner probes is measured
    - Current between outer probes is measured
    - Resistance and resistivity are calculated as shown below.

**Interpretation**

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

$$\rho = \frac{4\pi a R}{1 + \frac{2a}{\sqrt{a^2 + 4l^2}} - \frac{a}{\sqrt{a^2 + 4l^2}}}$$

$$\rho = 2\pi a R \qquad l \ll a$$

- Unequally spaced 4-pin Method / Schlumberger Array: Modified version of Wenner 4-pin method. Provides greater sensitivity for large spacing.
  - **Procedure**
    - 4 electrodes of equal length 'l' are driven in a straight line as shown in formula
    - Voltage between inner probes is measured
    - Current between outer probes is measured
    - Resistance and resistivity are calculated as shown in formula

**Interpretation**

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

$$\rho = \frac{\pi a(a + 2b)R}{2b}$$

$$\rho = \frac{\pi a^2 R}{2b} \qquad a \gg b$$

- Variation of Depth Method / Driven Rod Method: This method is based on the Fall-of-Potential method
  - **Procedure**
    - Test rod has diameter 'd' and it is driven into ground to a length 'l'
    - Reference rods are driven to a shallow length in a straight line.
    - Current is measured between Rod 1 and Rod 2
    - Voltage is measured between Rod 1 and Rod 3.

**Interpretation**

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

$$R = \frac{\rho}{2\pi l}\left[\ln\frac{4l}{\left(\frac{d}{2}\right)} - 1\right] \rightarrow \rho = \frac{2\pi l R}{\left[\ln\frac{4l}{\left(\frac{d}{2}\right)} - 1\right]}$$