

Power System Grounding



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Objectives of Grounding: Power Station/substation grounding

- Earthing/Grounding is should be done to achieve the following objectives:
 - ✓ To ensure safety to personnel in substations against electrical shocks.
 - ✓ To provide the ground connection for connecting the neutrals of stat connected transformer winding to earth (neutral earthing).
 - ✓ To discharge the over voltages from overhead ground wires or the lightning masts to earth. To provide ground path for surge arresters.
 - ✓ To provide a path for discharging the charge between phase and ground by means of earthing switches.
 - ✓ To provide earth connections to structures and other non-current carrying metallic objects in the sub-station (equipment earthing).

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Definitions:

- Grounding is the act of connecting a conductor, or exposed conductive parts of an installation, to the earth.

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Earth Mat in
110kV side of
a 220/110 kV
Substation

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Tolerable limits of body currents: Physiological Effects electric current on Human Body as per IEC 60479

- *The effect of passing alternating current (50 Hz) through the body from hand-to-hand:*

Current (mA)	Physiological effect
0.5–2	Threshold of perception
2–10	Painful sensation, increasing with current. Muscular contraction may occur, leading to being thrown-off
10–25	Threshold of 'let go', meaning that gripped electrodes cannot be released once the current is flowing. Cramp-like muscular contractions. May be difficulty in breathing leading to danger of asphyxiation from respiratory muscular contraction
25–80	Severe muscular contraction, sometimes severe enough to cause bone dislocation and fracture. Increased likelihood of respiratory failure. Increased blood pressure. Increasing likelihood of ventricular fibrillation (uncoordinated contractions of the heart muscles so that it ceases to pump effectively). Possible cardiac arrest
Over 80	Burns at point of contact and in internal tissues. Death from ventricular fibrillation, cardiac arrest, or other consequential injuries

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Body current depends on (physiological impacts)....

- Magnitude of voltage/current
- Duration of current through the body
- Dry or wet skin/surface
- Resistance of body (body weight)
- Path taken by current through the body

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Soil Resistivity ($\Omega.m$):

- Soil resistivity testing is the process of measuring a volume of soil to determine the conductivity of the soil. The resulting soil resistivity is expressed in ohm-meter or ohm-centimeter.

OR.....

- The measure of the resistance offered by the soil in the flow of electricity, is called the soil resistivity.

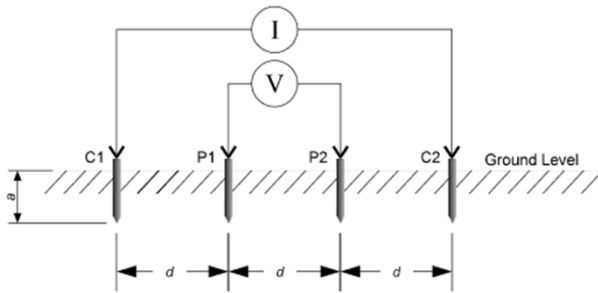
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The resistivity of the soil depends on

- soil composition/type of soil
- moisture
- Temperature

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Earth Resistance measurement:



Wenner 4 Pin Method

Fig: Resistivity Probe Configurations

Equation of resistivity = $\rho = 2 \pi a R$

a- spacing between the probes,
R- resistance measured by the meter

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Earth Resistance measurements: IS:3043, 2010

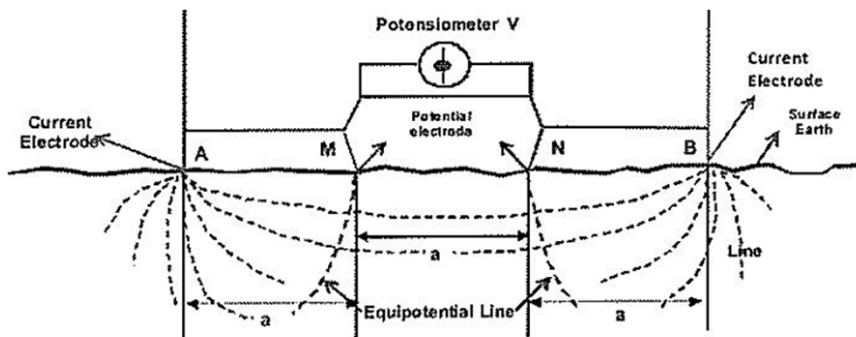


Fig: Resistivity Probe Configurations

Source: <https://hurricane193.wordpress.com/>

Equation of resistivity = $\rho = 2 \pi a R$

a- spacing between the probes,
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Earth Resistance measurements: IS:3043, 2010

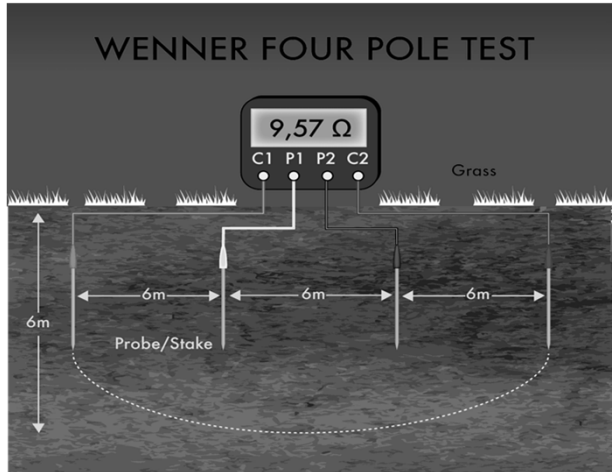


Fig: Resistivity Probe Configurations

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a- spacing between the probes,
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Earth Resistance measurements: IS:3043, 2010

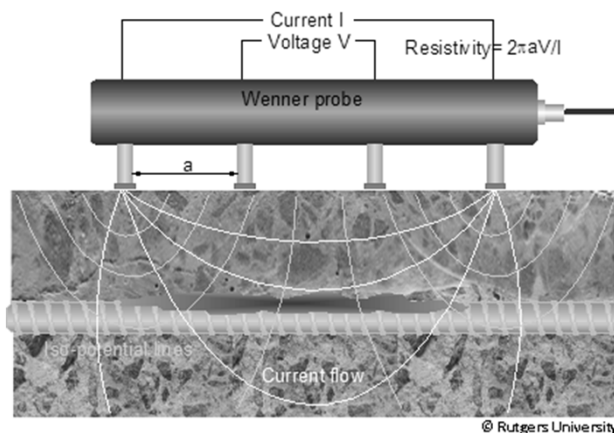


Fig: Resistivity Probe Configurations

Source: Rutgers University

Equation of resistivity = $\rho = 2 \pi a R$

a- spacing between the probes,
R- resistance measured by the meter

Earth Resistance measurements: IS:3043, 2010

Type of Soil or Water	Typical Resistivity Ωm	Usual Limit Ωm
Sea water	2	0.1 to 10
Clay	40	8 to 70
Ground well & spring water	50	10 to 150
Clay & sand mixtures	100	4 to 300
Shale, slates, sandstone etc	120	10 to 100
Peat, loam & mud	150	5 to 250
Lake & brook water	250	100 to 400
Sand	2000	200 to 3000
Moraine gravel	3000	40 to 10000
Ridge gravel	15000	3000 to 30000
Solid granite	25000	10000 to 50000
Ice	100000	10000 to 100000

Table 1-1 Resistivity values for several types of soils and water

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Step Potential & Touch Potential

- **Step potential** is the step voltage between the feet of a person standing near an energized grounded object.

OR....

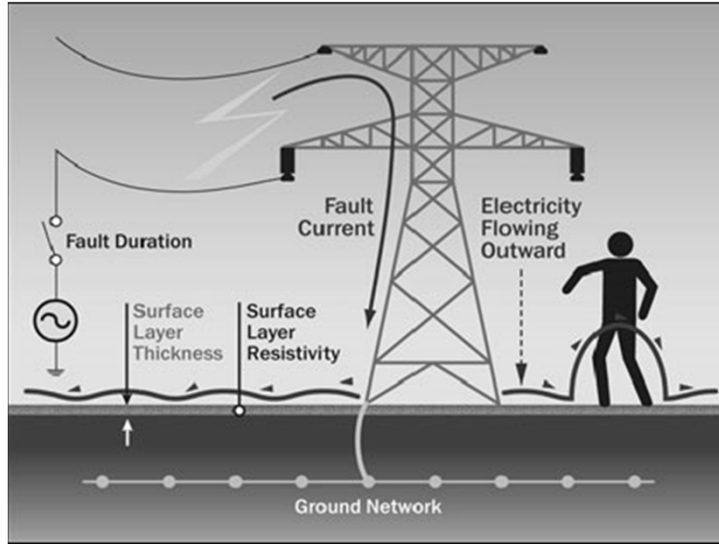
- A person walking on earth surface will experience a voltage between his/her feet. This voltage will generate body current. This is called step voltage.
- **Touch potential** is the touch voltage between the energized object and the feet of a person in contact with the object.

OR....

- The potential difference from the point of earth at which person is standing. This will generate body currents which a person is subjected is called touch voltage.

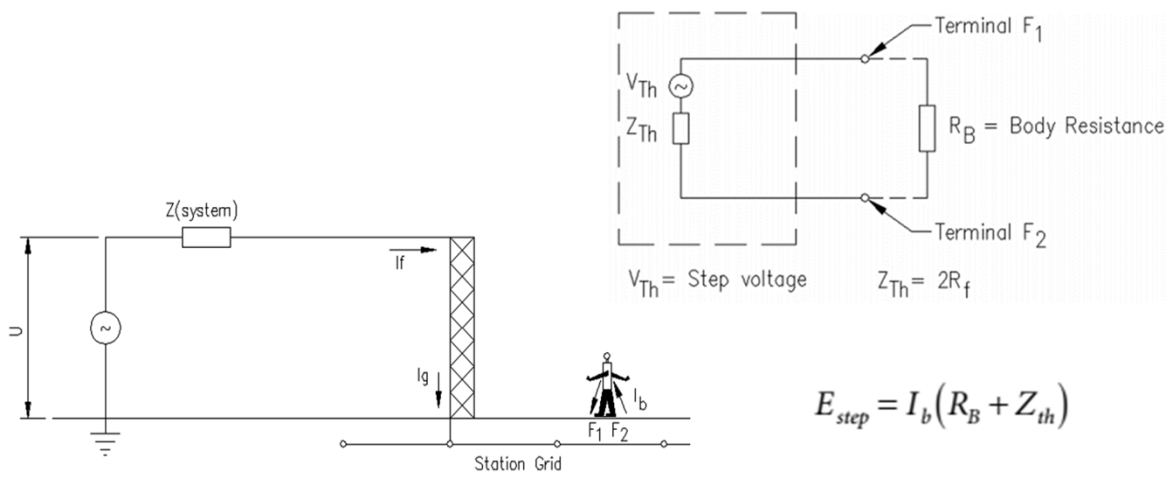
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Step Potential



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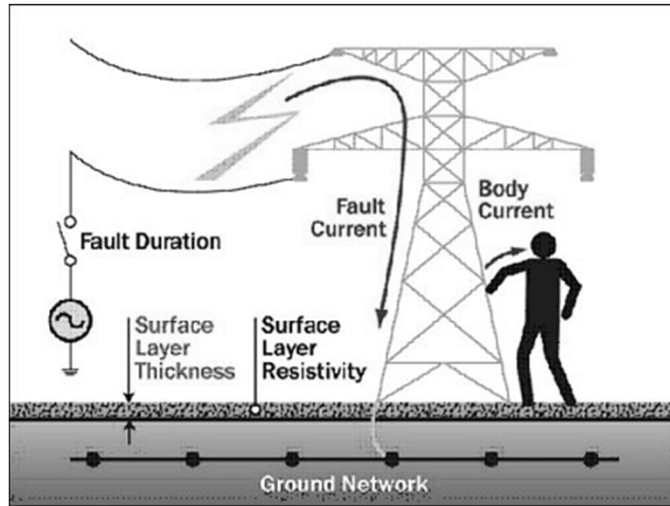
Exposure to step voltage



$$E_{step} = I_b (R_B + Z_{th})$$

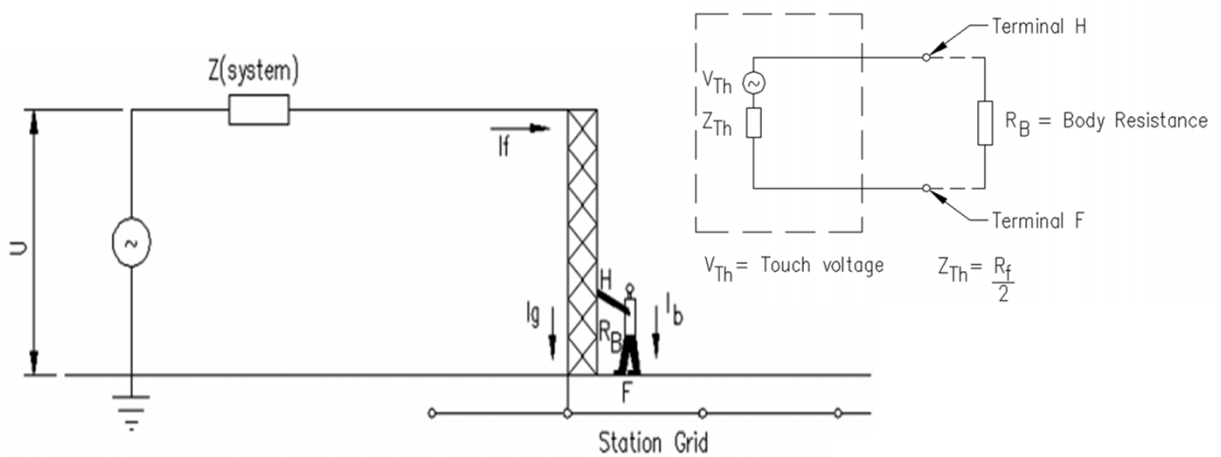
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Touch Potential



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Exposure to touch voltage



$$E_{touch} = I_b (R_B + Z_{th})$$

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- **Metal-to-metal touch voltage:**

The difference in potential between metallic objects or structures within the substation site that can be bridged by direct hand-to-hand or hand-to-feet contact

- **Ground potential rise (GPR):**

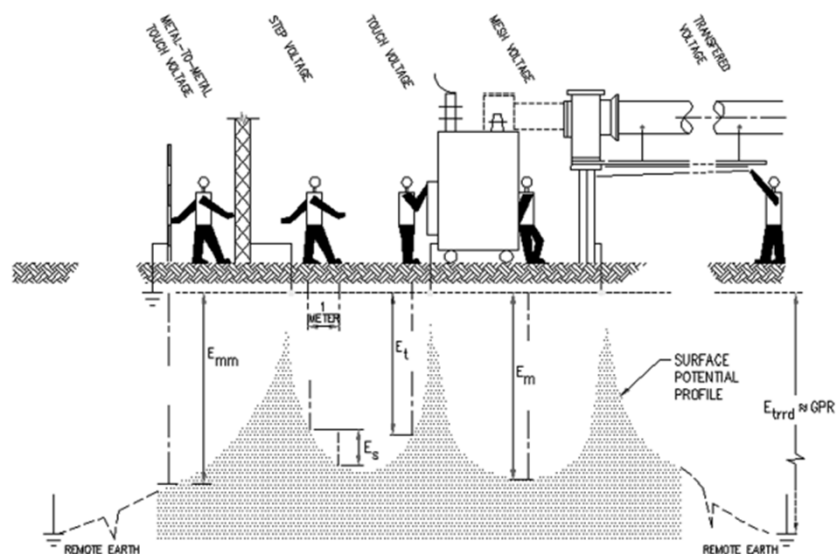
GPR is the product of the magnitude of the grid current, the portion of the fault current conducted to earth by the grounding system, and the ground grid resistance

- **Mesh voltage:**

The maximum touch voltage within a mesh of a ground grid

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Basic shock situations



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