

In most cases the resistivity is function of depth $\rho = f(z)$

Before any design a good study of the area where the grounding will be installed, the information about the soil and soil nature and configuration.

How we do the measurement :

There are several methods to obtain such thing. Each method will be discussed.

Variation of depth method

In this method several ground tests done at several depth. Using an earthed electrode. Each time the depth of the burial electrode increased. The measured resistance value will then reflect the variation of resistivity at increased depth. If a large volume of soil must be investigated, it is preferable to use the four-point method, since the driving of long rods is not practical. . . . later

Two point method

Since this method is suited only for determining the resistivity of small volumes of soil, it is not recommended that extrapolation of the results be attempted.

Four point method

Small electrodes are buried in four small holes in the earth, all at depth b and spaced (in a straight line) at intervals a . A test current I is passed between the two outer electrodes and the potential V between the two inner electrodes is measured with a potentiometer or high-impedance voltmeter. Then V/I gives the resistance R in ohms.

There are two aspects for the four point method

1. Equally spaced (WENNER METHOD)

In this method the electrodes are equally spaced. At the distance between the two electrode

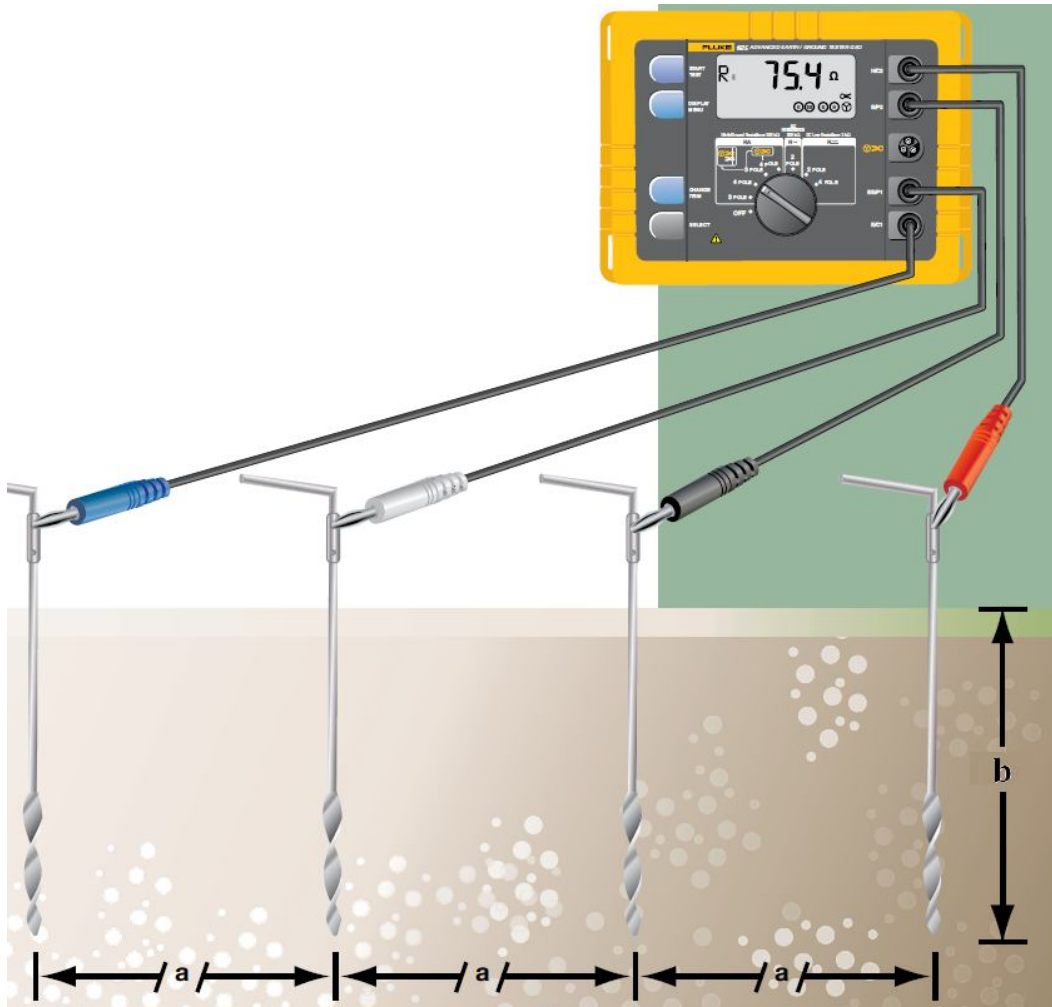
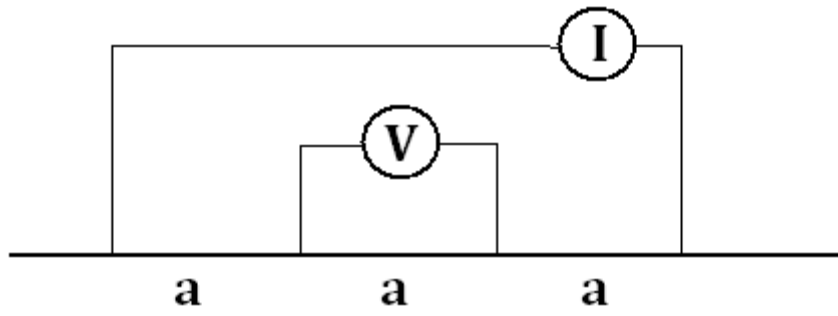
$$\rho = \frac{4\pi aR}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

four rods are usually placed in a straight line at intervals a , driven to a depth not exceeding $0.1 a$. Then we assume $b = 0$ and the formula becomes:

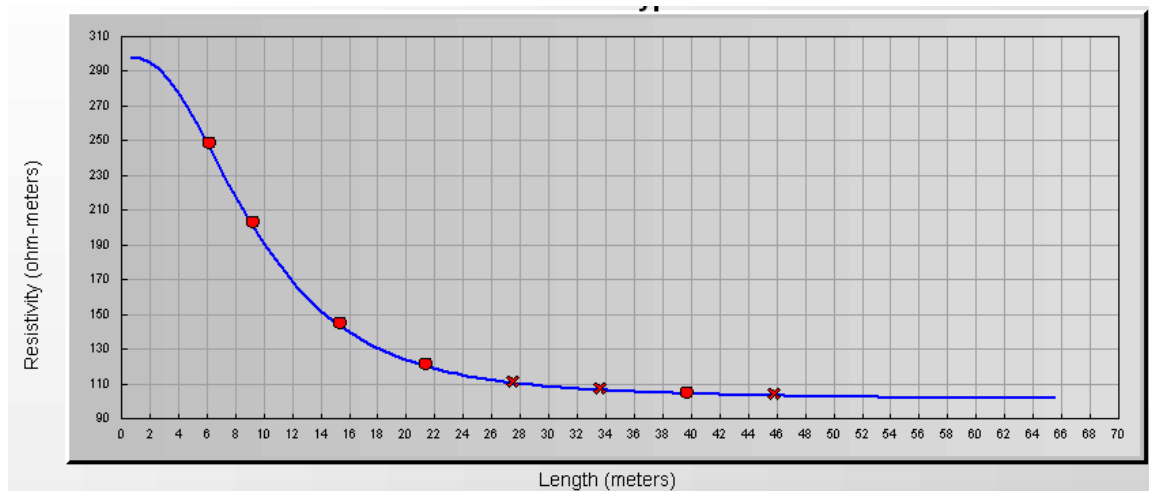
$$\rho = 2\pi aR$$

and gives approximately the average resistivity of the soil to the depth a .

a set of tests done for different spacing, then a curve is plotted against spacing, indicates whether there are distinct layers of different soil or rock and gives an idea of their respective resistivities and depth.



Example of measurement :



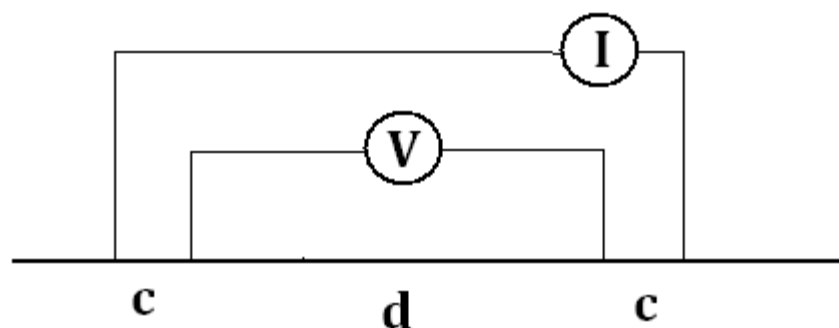
1. *Unequally-spaced or Schlumberger-Palmer method*

When performing wenner method as the distance between the electrodes increases the potentials between them decreased , some commercial instruments can't measure these low potential values. So in order to be able to measure resistivity for large spacing this method is used.

The outer electrode can be moved four or five times for each move of the inner electrode

If the depth of burial of the electrodes b is small compared to their separation d and c , then the measured resistivity can be calculated as follows:

$$\rho = \pi c(c + d)R/d$$



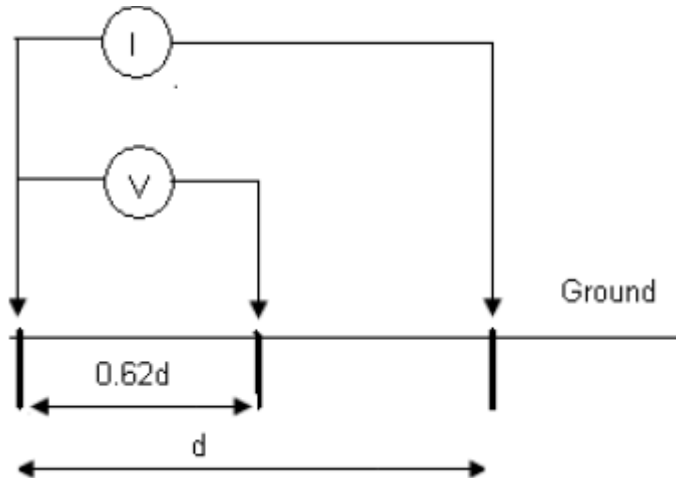
Driven Rod Method

This method is also called the three probe method or three pin method

$$\rho = 2\pi l R / \ln(8l/d)$$

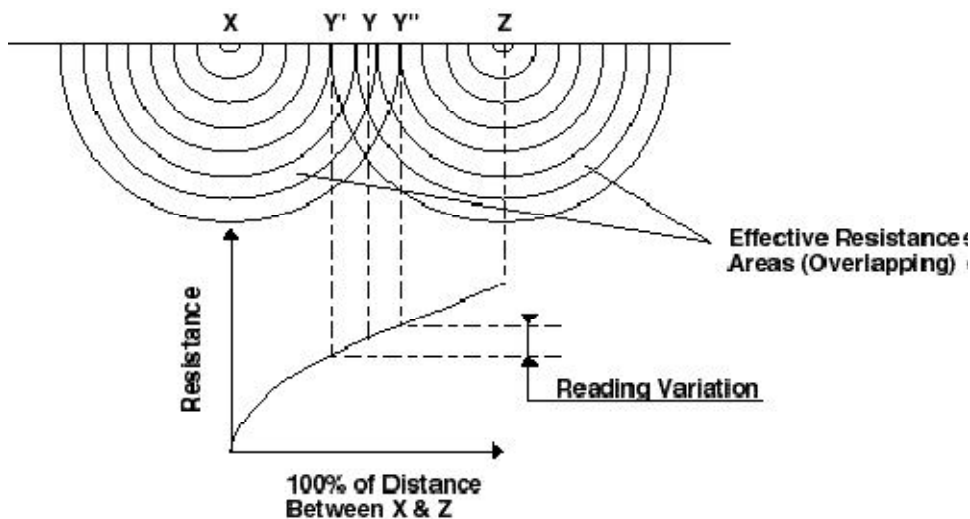
l is the length of driven rod in contact with earth

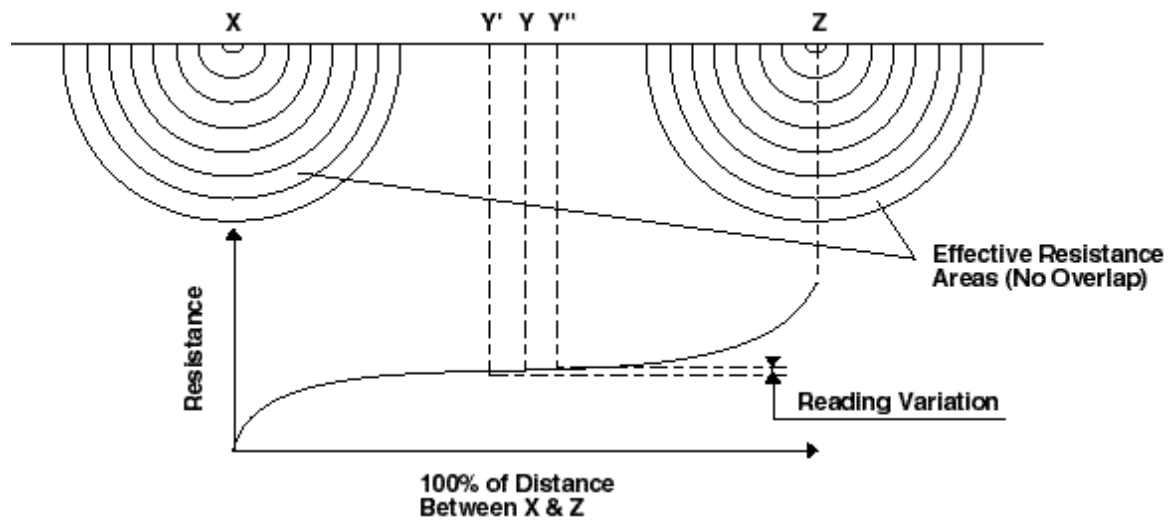
later. . . .



Position of the Auxiliary Electrodes on Measurements

The goal in precisely measuring the resistance to ground is to place the auxiliary current electrode Z far enough from the ground electrode under test so that the auxiliary potential electrode Y will be outside of the effective resistance areas of both the ground electrode and the auxiliary current electrode. The best way to find out if the auxiliary potential rod Y is outside the effective resistance areas is to move it between X and Z and to take a reading at each location. If the auxiliary potential rod Y is in an effective resistance area (or in both if they overlap), by displacing it the readings taken will vary noticeably in value. Under these conditions, no exact value for the resistance to ground may be determined





The data obtained from each result must be carefully studied. Deep analysis of the curves must be done to obtain the configuration of the soil.

For applications in power engineering, the two-layer equivalent model is accurate enough without being mathematically too involved.