Performance of Multylayers Smart Earthing System

[1]Nofal M. Hussein and [2]Shaymaa H. Nofal
[1]College of Engineering,
[2]Department of Biomedeica Engineering, College of Engineering,
Warith Al-Anbia University, Kerbala, Iraq

Abstract: Vertical ground multylayers copper cylindrical earthing design have been used extensively for earth termination of electrical and lightning protection system. The experimental work shows that the efficiency of the design earthing system is much higher than the sound earthing cylinder which is more costing than that the multylayers design. Also, the other parameters such as current density, resistance and surface area, effected and shows relatively high result in cause of multylayers earthing system.

Key words: Earthing system, earth electrode, soilresistivity, TEP, earthing, costing

INTRODUCTION

Grounding or earthing described as electrical system connections to the earth mass. This system consists of electrical part and metal works associated with equipment, apparatus and appliance. The function of grounding to provide a path for the fault currents to the soil while maintaining the step and touch voltages at acceptable values, for limiting potential with respect to the earth mass to ensure safety. Earthing system designed with "zero impedance" to provide effective discharge of fault currents and prevent the potential rise at and around the substation. To get adequate grounding system performance, the system should be designed with low earth impedance and to get the optimum design of earthing systems can be achieved two parameters-earth electrode geometry and soil properties. In general resistivity soil range from a few Ω-meters for clay soil to several kilo-Ω-meters for rocks (ANSI/IEEE Std., 1983; Nor *et al*., 2000, 2006). Describing the change in resistivity for different soil type, grain size, temperature, moisture and salt content are important. Experimental work using wet clay mixed with sand under controlling amount at NaCl to get a range of low resistivity materials were performed (Nor *et al*., 2006) . The result shows that under impulse conditions, the apparent resistivity of wet clay decreased with increasing current ranges, suggest nonlinear soil-ionization. Generally, power systems are protected from lightning strokes by surge arresters provided with a low earth resist connection to keep large currents encountered to be effectively discharged to the general mass of earth which resist the flow of current. Earth resistance depends on arrangements and design of electrode, surrounding type of soil and there resistance. Combinations of different materials are used for ground resistance reduction, the results show considerable reduction in the grounding resistance can be achieved when using such materials which in turn guided to improve performance of grounding (Al-Ammar *et al*., 2010). Ground rods vertically have been used for earth termination of electrical and lightning protection systems. The result of a comparison between three models for frequency dependent simulation of a ground rod: Lumped R-L-C circuit, the distributed-parameter circuit and the EM Model show significant differences at high frequencies. In the lumped circuit R-L-C Model is limited to cases where the length of the rod is >1-10 th of the wavelength in Earth, this limits the frequency range of the validity of this model to some lower frequencies, depending on the EM properties of the soil and of the rod. At higher frequencies, the model greatly overestimates the impedance to ground (Grcev and Popov, 2005).

Field tests of variable frequency (DC to 10 MHz) on different earth rod length reveal the benefits of extending rod length on low frequency performance, although these gains are less significant with longer rods. The steady indicate that higher frequencies, rod length extension may counterproductive with higher values of impedance record for the longer rods. The result shows relatively high agreement between experimental and simulation result is obtained (Mousa *et al*., 2012). A significant parameters of a 3-Gw 200-Kv DC superconducting cable system which influence the transient voltage distribution in the various park of the system cable was investigate it was found that the severity of the transient voltages are effected with the dielectric constant and the electrical resistivity of the soil (Pallem *et al*., 2006).

Investigation of the frequency depended behavior of the typical grounding systems for wind turbine was analysed. The system buried in a two dage soil. The relation between the various resistivity values and the alterations of the thickness of two soil layers was

examined. It was found that the touch voltage is depended upon the parameters of soil structure, shape and dimensions of the grids (Kontargyri *et al*., 2005).

The objective: The aim of this study is to design a multilayers cylindrical copper earthing electrode with soil stated between the layers to increase the present rates of the lightening effects.

MATERIALS AND METHODS

Experimental work: Two parameters affecting the electrical properties of earthing system, they are the earthing resistance and configuration of the earth electrode. The earthing resistance is relationship between earth voltage and the earth current value. The earth electrode configuration means the potential distribution on the earth surface due to the result of current flow in the earth. To achieve low values of earth resistance, the current density of metal electrode flow to earth should be low in this cause the earth volume surrounding the electrode should be as lower as possible.

Copper sheet of 2 mm thickness used to manufacturing four cylindrical pipes shapes with the same length of 100 cm and different diameters of 6, 8, 10 and 12 cm, each of them connected with copper wire of 2.5 mm diameter all the wire brought together to be one wire of 10 mm diameter as shown in Fig. 1.

It can be seen from Fig. 1 that the variation is much more significant for the earthing multylayers system due that to two side of contact effect with soil as compare with sound cylindrical earthing electrode.

Impulse measurements: The number of earthing electrode and earthing resistance depends on the resistance of soil and time for fault current to posse through. Low voltage was carried out on the same earthing cylinders configuration which shown in Fig. 1. The Transient Earthing Potential (TEPR) rise for different surface area of earthing cylinder for a fixed current transmitted. From the figure, it can be seen that, for a fixed current transmitted, the voltage and current peaks occur at the same time for all cylinders indicating a predominantly a resistive response. In all cylinders the peak voltage decreases as the cylinder surface area increases.

Calculations
Current density:

$$\left[I = 7.57 \times 1000 / \left(\sqrt{\rho \times t} \right) \right] Am^{-2}$$

Resistivity of soil 500 (Ω m) silty sand, poorly graded sand-silt mixtures ρ t = time dissipated (Table 1).

- Surface area of pipe:
- $A = 2 \pi r L$
- $\pi = 3.14$
- $r = d/2$ d = diameter of electrode
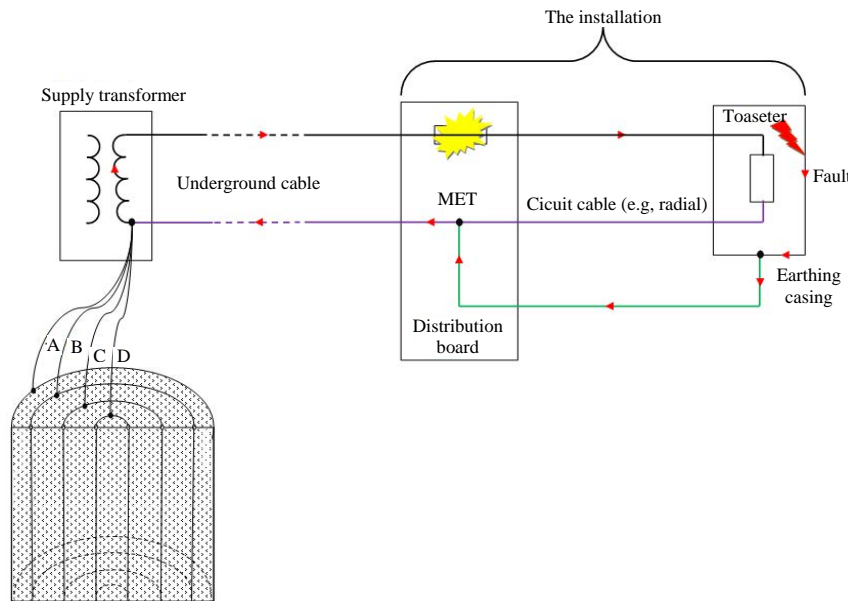- L = Length of electrode (100 cm) current dissipated (Table 2)

Fig. 1: Schmatic diagram of the earthing system

Table 1: Current density

t = time dissipated (sec)	Current density (Am^{-2})
1	338.54
2	239.38
3	195.46
4	169.27

Table 2: Surface area of pipe

Reduce (m)	Current density (A m^{-2})	Surface area (m^2)
0.03	338.54	0.3768
0.04	239.38	0.5024
0.05	195.46	0.6280
0.06	169.27	0.7536

Table 3: Current dissipated

Current density (A m^{-2})	Surface area (m^2)	Current dissipated (A)
338.54	0.3768	127.61
338.54	0.5024	169.93
338.54	0.6280	212.58
338.54	0.7536	255.23
239.38	0.3768	90.25
239.38	0.5024	120.18
239.38	0.6280	150.34
239.38	0.7536	180.51
195.46	0.3768	73.71
195.46	0.5024	98.14
195.46	0.6280	122.77
195.46	0.7536	147.41
169.27	0.3768	63.83
169.27	0.5024	84.99
169.27	0.6280	106.32
169.27	0.7536	127.65

Table 4: Current resistance

Diameter (m)	Resistance (Ω)1	Resistance (Ω)2	Resistance (Ω)3	Resistance (Ω)4
0.06	168.9227	168.6604	168.3961	168.1298
0.08	158.8882	158.5371	158.1825	157.8241
0.1	151.085	150.6445	150.1983	149.7463
0.12	144.6931	144.1625	143.6236	143.0762

Current dissipated:

- $I_d = I \times A$
- A = Surface area
- I = Current density (Table 3)

R = ρ/2*3.14*L (loge (8*L/d)-1):

- = Resistivity of soil
- d = diameter of electrode
- L = Length of electrode (100 cm) (Table 4)

RESULTS AND DISCUSSION

Figure 2 shows the relation between current density and lighting time. The current density decreases as lighting time increases for multylayers earthing system, this induct that the distribution of current through the soil is effected by the increasing of contact air between soil and earthing system.

Figure 3 shows that the current density is effected by the increasing the soil earthing surface area of the each layer, so as the area of each soil layer increased the current can be dissipated vastly and required less time.
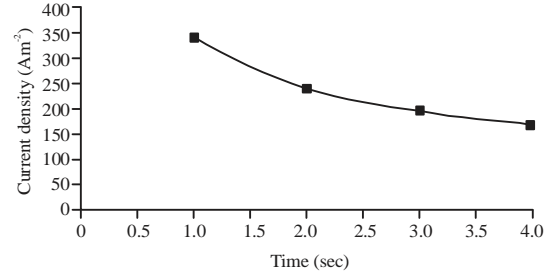

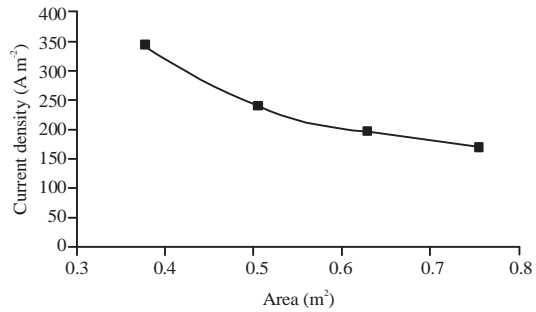Fig. 2: Current density change with lighting time

Fig. 3: Current density change with contact area between soil and copper contacted areas
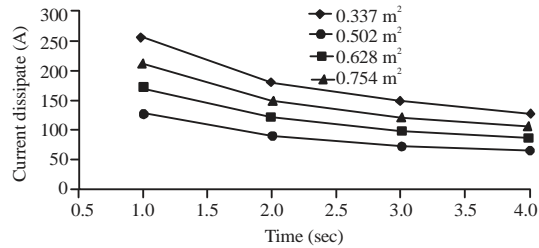

Fig. 4: Current dissipated change with lighting time for different surface area of copper

Figure 4 shows the relationship between current density and lighting time for different areas, so that, the general behavior is uniform but there is a significant effect of the area of each copper layer of the earthing system on the lighting time period.

Figure 5 shows the relationship between the surface area of the layer and the rate of current dissipated relative to the lighting time where the greater the surface area the higher the dissipated of current is greater and this indicates that the contact area between the surface layer of copper and soil is larger.

At contact lighting time period the current dissipated rate increased as the contact area between soil and copper increased also as the lighting time increased the current dissipated decreased at constant area between soil and copper.
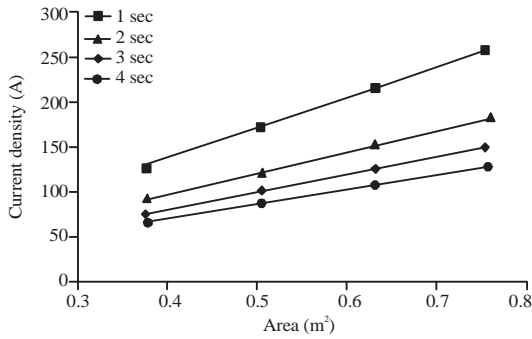
Fig. 5: Current dissipated change with surface area of copper for different lighting time
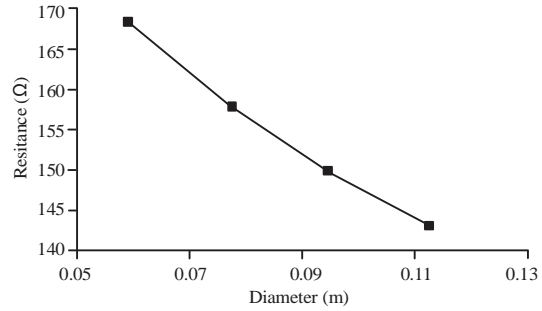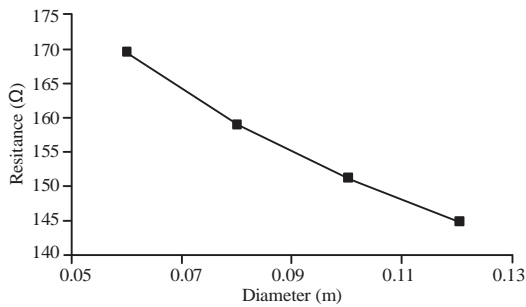

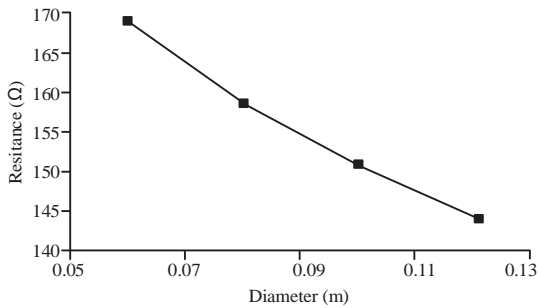Fig. 6: Ground cylinder resistance versus diameter (for 1 m length)

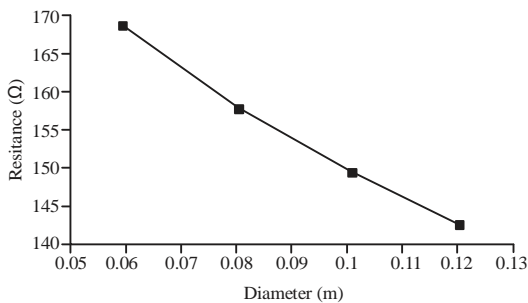Fig. 7: Ground cylinder resistance versus diameter (for 1 m length)

Fig. 8: Ground cylinder resistance versus diameter (for 1 m length) (3 sec lighting time)

Fig. 9: Ground cylinder resistance versus diameter (for 1 m length) (4 sec lighting time)

Figure 6-9 show that the resistance of earth against the lighting current decreases while increasing the diameter of the cylindrical copper, this due to the increased in contact area between soil and copper surface, the shape of the relation is effected by the lighting period which means that the lighting current take short time to dissipated.

CONCLUSION

This study has focused on designing of multylayers smart earthing system. It is important to increase the earthing resistivity to reduce the time of dissipated the spark. From the laboratory testing, the following conclusions can be drowned. Increasing the contact areas between metal and earth reduce the sparking effects. The current density decrease is effected by increasing of earthing surface area of each layer.

Spark current dissipated rate effected by the earthing cylindrical area with time. Ground cylinder resistance effected inversely with surface area of cylinder at any sparking period time. Multylayers earthing system cost is more cheaper than the cost of sound cylinder. In multylayers earthing system we get twice contact surface areas in this cause the dissipated spark current is lower.

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