Investigation of Mutual Coupling Between Two Grounding Electrodes in a Finite Conductivity Medium

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ABSTRACT

This article proposes, the modeling in transient state of the grounding systems (horizontal and vertical electrodes) using the finite difference centered point method (FDTD) coupling with the transmission line method in the semi-finite medium, to study mutual interaction between two groundings. The current and the voltage can be easily calculated, in any part and any instant, of each electrode using spatio-temporal discretization of finite difference method.

Keywords: Electrodes, FDTD, Mutual interaction

1 Introduction

The importance of the grounding systems design for overhead power transmission lines VHV or HV and substations is due to the need reduce the costs associated with ground electrodes installation [1], protect the equipment and improve the quality of service and limit overvoltage.

The reproducibility of ground electrode measurements is subject to unavoidable limits. This difficulty, which takes into account the soil environment with its different properties [2] (inhomogeneous, parallel and horizontal stratification, nonlinear, anisotropic, etc.), has led researchers to approach this problem by mathematical calculation with a few simplifying assumptions.

2 Calculate the distribution voltage and currents in ground excited by a temporal generator using the FDTD

The previous system of matrix equations is better known as coupled line theory. It is solution given by FDTD. First, it involves alternately subdividing a conductor into current and voltage nodes, then writing the equation of potential and current at each node (Figure. 1).

$$\begin{cases} (\mathrm{I})_k^n = \mathrm{I}((k-1)\Delta x, n\Delta t) \\ (\mathrm{U})_k^n = \mathrm{U}((k-1/2)\Delta x, n\Delta t) \end{cases}$$

After spatio-temporal discretization, the solutions become:

For k=1,…….kmax-1

$$\left[(\mathrm{I})_{k+1/2}^{n+1/2}\right] = \left[\frac{[\mathrm{R}]}{2} + \frac{[\mathrm{L}]}{\Delta t}\right]^{-1} \left\{ -\frac{\left[(\mathrm{U})_{k+1}^{n}\right] - \left[(\mathrm{I})_{k}^{n}\right]}{\Delta t} - \left[\frac{[\mathrm{R}]}{2} - \frac{[\mathrm{L}]}{\Delta t}\right] \right\} \left[(\mathrm{I})_{K+1/2}^{n-1/2}\right]$$

For K=2,……………Kmax-1

$$\left[(\mathrm{U})_{k}^{n+1}\right] = \left[\frac{[\mathrm{G}]}{2} + \frac{[\mathrm{C}]}{\Delta t}\right]^{-1} \left\{ -\frac{\left[(\mathrm{I})_{k+1/2}^{n+1/2}\right] - \left[(\mathrm{I})_{k-1/2}^{n+1/2}\right]}{\Delta t} - \left[\frac{[\mathrm{G}]}{2} - \frac{[\mathrm{C}]}{\Delta t}\right] \left[(\mathrm{U})_{k}^{n}\right] \right.$$

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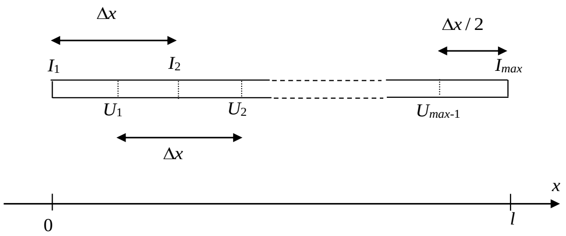

Figure 1: *Spatial discretization of an electrode.*

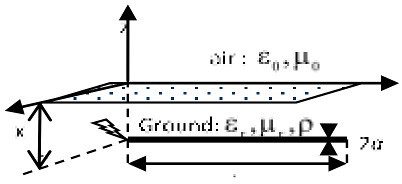

Figure 2: *Horizontally buried electrode.*

3 Results and Discussion

To validate the mutual interaction between two electrodes buried horizontally in a soil at finite conductivity using the applications treated by F. Dawallibi and Al [3] at low frequency, according to the tests proposed by S. Cattaneo and Al. [4]. The proposed tests for horizontally buried electrode is a rectilinear electrode of radius a, and length l (figure.2.) a "lightning wave" generator are:

Injection of a weak current pulse into a poorly resistant soil with representation of the voltage distribution (Figure 3).

Injection of a strong current pulse into a relatively resistant soil and deduction of the voltage in the electrode (Figure 4).

Representation of the variation in the transient impedance of the second electrode (Figure 5).

Finally, Figure 6 illustrates the distribution of the potential in the second electrode at different points.

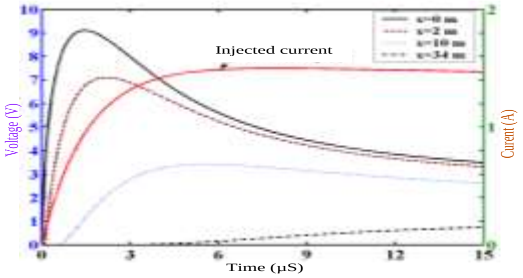

Figure 3. Variation of the potential at different points of the electrode.

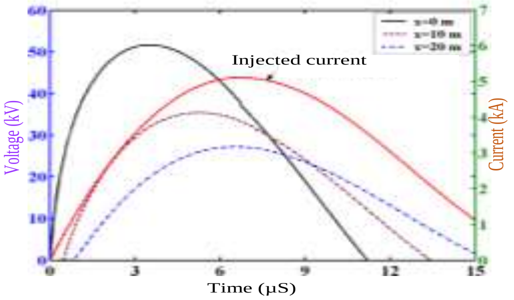

Figure 4. Variation of the potential at different points of the electrode

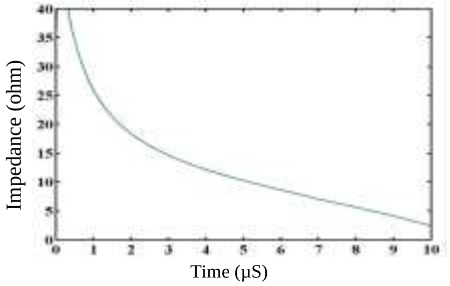

Figure 5. Variation of the transient impedance at the input of electrode

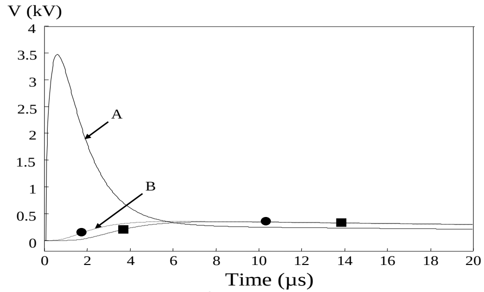

Figure 6. Variation of potential at Electrical coupling of the two electrodes groundings

The set of results obtained for two grounding electrodes clearly illustrate the behavior in terms of frequency and amplitude of the electrical voltages, currents, and impedances. For the distribution of the potential in the different points of second grounding, allows us to conclude that our model gives acceptable results.

4 Conclusion

The calculation results obtained for the distribution of voltages and the variation of transient impedance lead to the assertion that the direct resolution of the temporal line equations, with appropriate boundary conditions, allows for the treatment of the interaction between two buried electrodes in transient conditions with more than acceptable precision.

How to Cite

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