An Efficient Computer Code for the Analysis of Grounding Systems Using the Method of Moments

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Abstract—We present an efficient computer code based on the method of moments (MoM) for the analysis of arbitrary grounding systems embedded in a lossy soil.

Keywords- Grounding system; numerical method; method of moments (MoM); input impedance.

I. Introduction

Accurate analysis of grounding systems is an important topic in electromagnetic compatibility (EMC) studies. The importance mainly lies in the fact that grounding systems play a crucial role in protecting people and facilities from disturbances generated by faults, lightning strikes and other transients. The aim of this paper is to present an efficient computer code based in the Method of Moments for the analysis of grounding systems.

II. Code Structure

The proposed code is based on the mixed potential integral equation method presented in [1]. The tangential component of the total electric field over the grounding object is forced to zero in this method. By substituting the scattered field with the vector of magnetic potential and electric potential scalar and performing the expansion and testing procedure in the Method of Moments (MoM), linear algebraic equations can be obtained. Solving these equations yields the current distribution along the grounding system.

The structure of the code can be divided into three parts: 1) Input, 2) Kernel, and 3) Output as illustrated in Figure 1 (a). In the input part, one should define the geometry of the grounding system, the electrical parameters of the soil, and the frequency range of the simulation. In the Kernel part, all the numerical steps needed for the simulation of the grounding system response and the calculation of the input impedance are embedded, for example, finding the junctions, meshing the structure, and creating all the sub-matrices to calculate the input or mutual impedance, Z_{in} or Z_{12}. Finally, the user can plot the required part of the input impedance in the Output part. The code has been validated using as reference numerical results in [2].

III. Numerical Example

We consider a 60×60 m^2 grounding grid with 6×6 meshes buried at a depth of 0.5 m [2] as shown in Figure 1 (b). In this figure, the solid-black lines, blue circles and red crosses show the ground electrodes, the nodes, and the excitation port (the lightning attachment point), respectively.

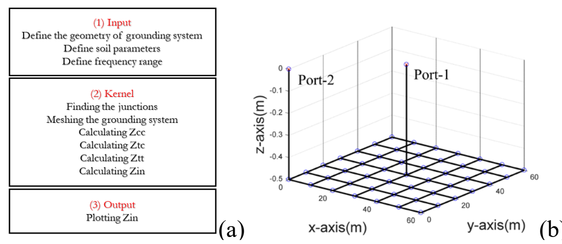

Figure 1. (a)The structure of the code for the analysis of grounding systems. (b) A 60×60 m^2 grounding grid with 6×6 meshes buried at a depth of 0.5 m.

The grid is composed of 7-mm radius rods. In Figure 1 (b), Port-1 and Port-2 are considered to be located at the center and at one corner of the grid, respectively. The soil is characterized by a permittivity of $\varepsilon = 9$.

The magnitude of the input impedance of the considered grounding grid is shown in Figure 2 for different soil conductivities. The obtained results are consistent with the results presented in [2].

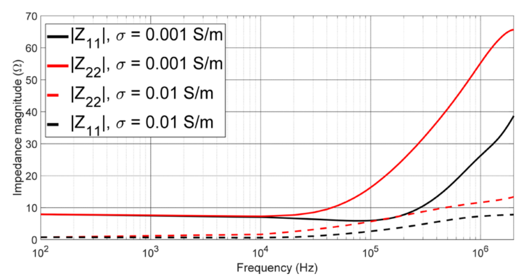

Figure 2. Magnitude of the input impedance of the 60×60 m^2 grid buried at 0.5 m depth in a homogenous soil excited from the center and corner ports as shown in Figure 1.

The main advantage of the MoM is that the mesh cells needed to solve the problem is limited to the grounding structure only, unlike other numerical methods such as finite-difference time-domain or finite-element methods. Future work includes the extension of the code to take into account stratified soils.

References

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