# Modeling of Grounding Systems Considering the Soil Ionization Effect Using COMSOL Multiphysics® Software

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## Introduction

The soil ionization is an important phenomenon to be considered in the analysis of grounding electric systems. When lightning strikes a grounded structure, the electric oeld associated with the high impulsive current injected into the grounding conductors may cause the soil around them to breakdown (see Figure 1).

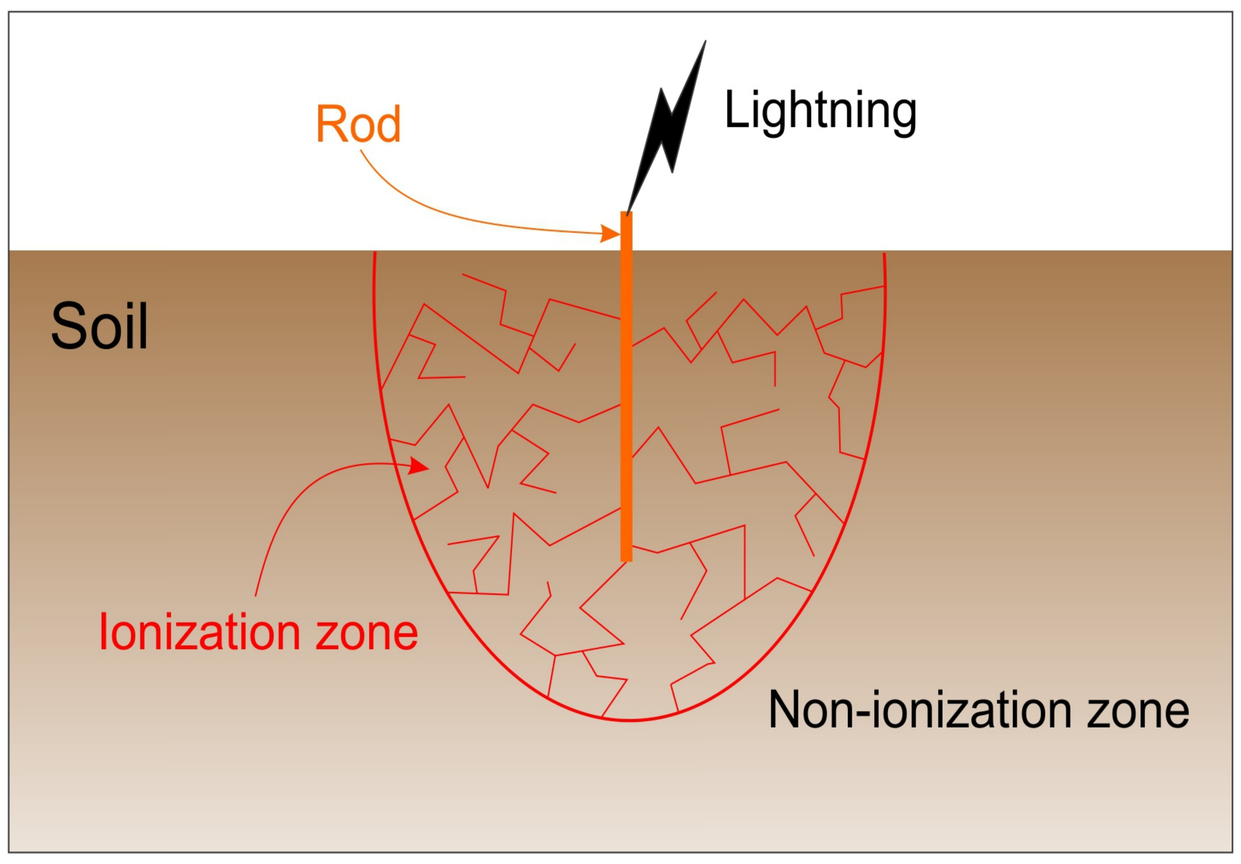


Figure 1: Ground electrode associated with soil ionization.

This phenomenon causes a decrease in the electric potential in the area of soil ionization and consequently reduces the value of the ground impedance . Several mathematical models have been proposed to take into account the dynamic effect of soil ionization on grounding systems submitted to lightning currents. Some of them, like the Dynamic Model (DM) and the Energy Balance Model (EBM) make use of analytical functions to represent the space-time variation of the soil resistivity.

In this way, the main goal of this work is to use the software COMSOL Multiphysics® as a modeling tool for grounding topologies subjected to lightning currents, taking into account the soil ionization effects predicted by the DM and EBM methods. Although COMSOL has been used successfully for many years in solving a lot of physical and engineering problems, apparently it has not been used in applications involving the transient behavior of grounding systems. Then, another objective of this work is to demonstrate that this software appears as an attractive alternative to be used as a computational tool in studies related to this subject matter.

## COMSOL Multiphysics Utilization

To perform the time domain simulations, the ***AC/DC Module*** was used. The 3D domain was discretized using ***ExtraFine adaptive*** meshes. Figure 2 show a dowchart of the algorithm of the proposed procedure developed to implement the soil ionization methods using ***LiveLink™ for MATLAB®***.

The geometric and mesh characteristics used to model a eDouble TI type concrete pole base are presented in Figure 3.

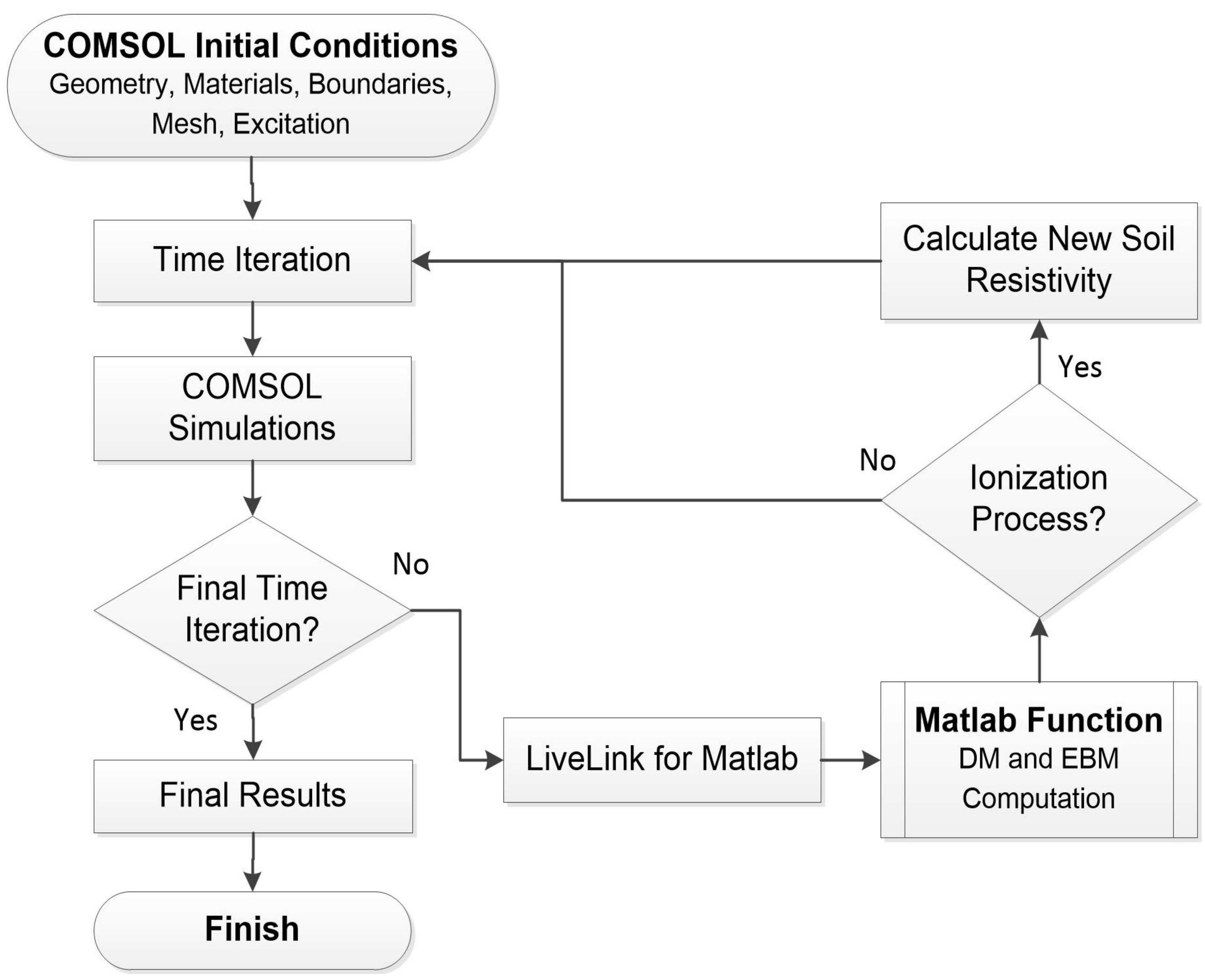


Figure 2: Flowchart of COMSOL simulation procedure

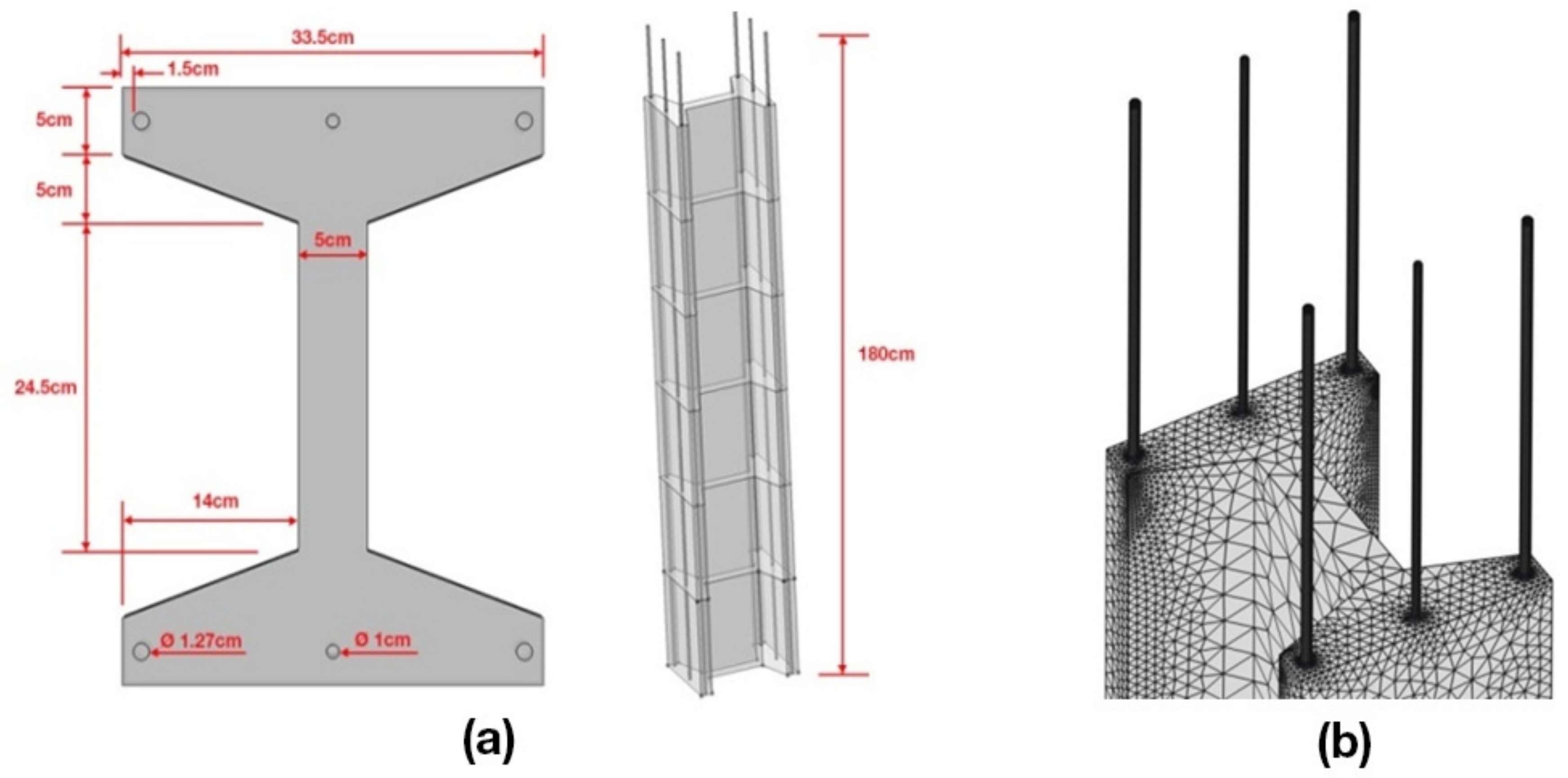


Figure 3: Geometric dimensions of the simulated concrete pole base

## Results

As example in this poster, the modeling and simulation results for a concrete pole base acting as a grounding topology for overhead power distribution lines are shown. The distribution of the equipotential lines is shown in Figure 4a. Based on these equipotential lines, regions were deoned in order to better modeling the soil ionization phenomena. These regions can be seen in Figure 4b.

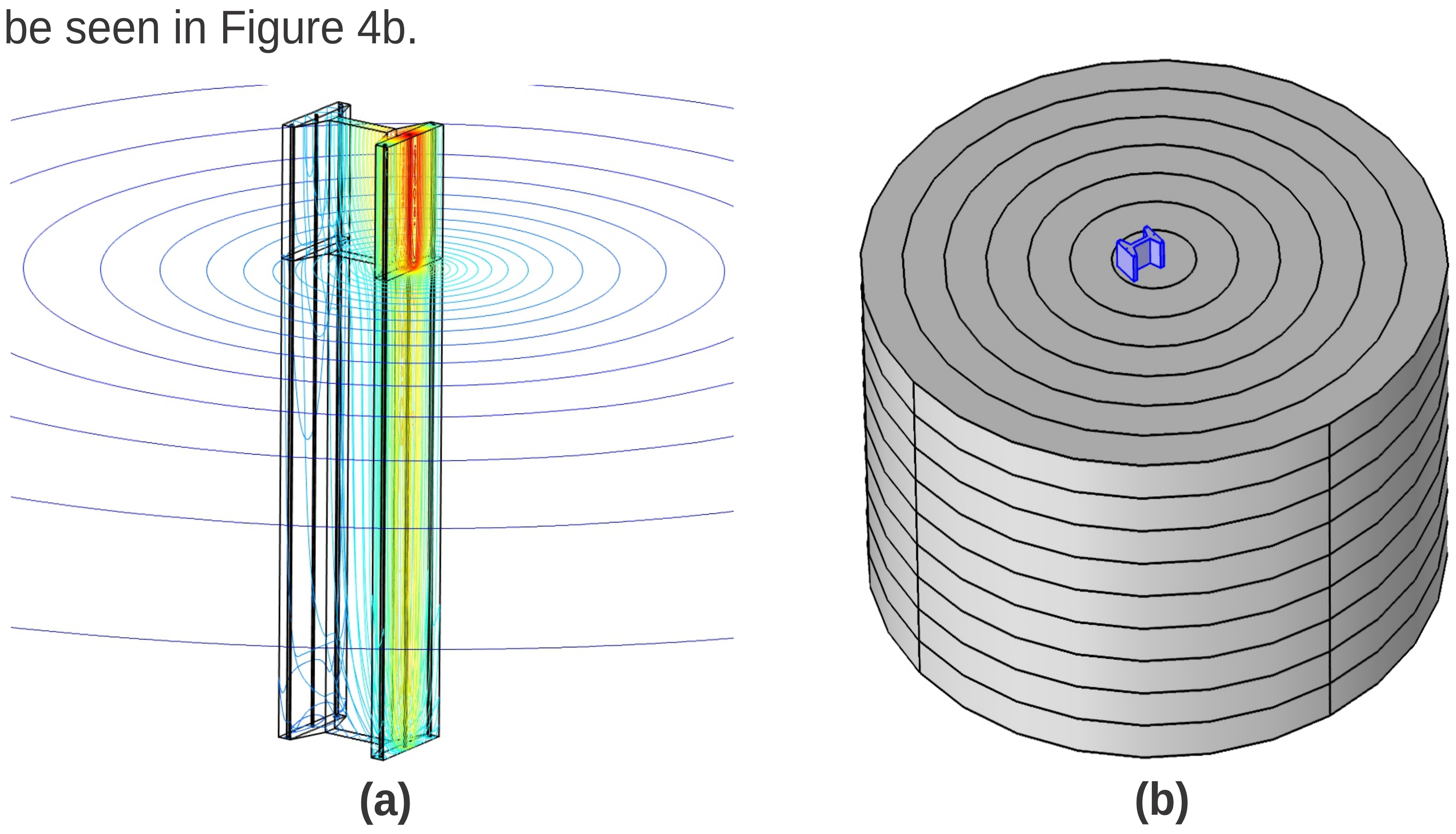


Figure 4: a) Distribution of the equipotential lines for a concrete pole base;
b) Soil Ionization Regions

Furthermore, Figures 5a and 5b show the voltage at the injection point and the transient ground impedance obtained for the DM and EBM models, besides the non-ionization response.

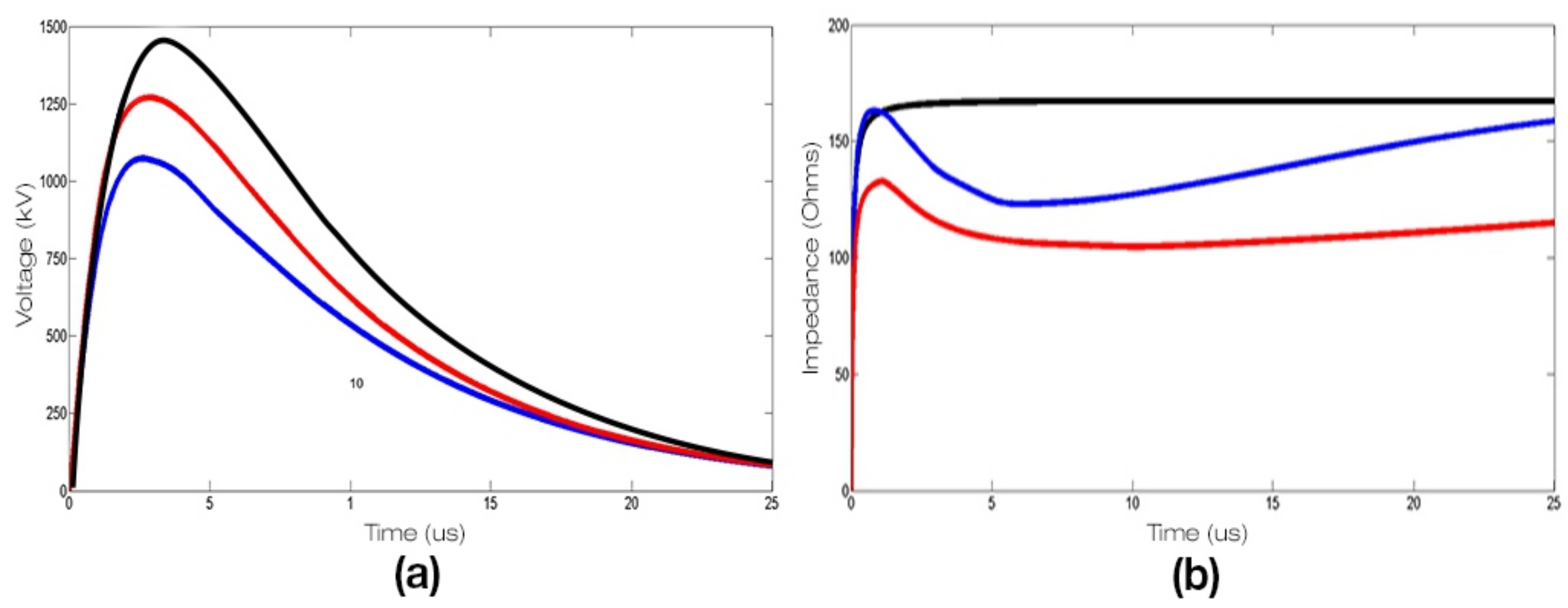


Figure 5: Simulation results: a) voltage at the injection point; b) transient ground impedance (DM blue, EBM red and Non-Ionization black)

## Conclusions

This work has proposed a procedure that allows modeling grounding systems with COMSOL Multiphysics® and MATLAB® taking into account the soil ionization effects according to the Dynamic and Energy Balance models. Comparisons between calculated results and those reported in the technical literature showed a satisfactory agreement. Also, a thermal study with COMSOL is planned in order to evaluate the temperature rise of the concrete to verify if it reaches the boiling point near the reinforcement rods for anticipated power system fault currents. Moreover, simulations are being done in order to study the behavior of ionization models for other typical grounding topologies used in electric distribution systems.

Excerpt from the Proceedings of the 2014 COMSOL Conference in Curitiba