Application of the finite elements method to the capacitance calculation

Jose-M. Bueno-Barrachina [1], César-S. Cañas-Peñuelas [1] and S. Catalan-Izquierdo [1]

[1] 1. Instituto de Tecnología Eléctrica
Universidad Politécnica de Valencia
Edificio 5E, Tercera Planta
Camino de Vera s/n 46022 Valencia (España)
phone:+34 96 3877593, fax:+34 963877599, e-mail: jmanuel.bueno@ite.es, cscanas@ite.upv.es, scatalan@ite.upv.es

1. Abstract

In this work we calculate by means of the finite elements method, the capacitance of a unit cube and the capacitance of a plane plates capacitor, taking into account the geometry parameters and the insulating medium that surrounds them. The obtained results are compared with previous released works.

Key words: Modelling, Electric Field, Capacitance, Finite Elements Method, Edge-effect.

2. Introduction

The most popular instrumentation used in the Electrical Engineering, presents edges that in the presence of an important electric field, act like as concentrating of electrostatic load and for they turn in the points with major probability of acting as way of an electrostatic discharge.
The study from the electrostatic point of view of the behaviour of an edge, presents a singularity, since in this point the equations of continuity are not applicable.
To calculate the existing load in these singularities, there have developed numerous studies and equations[1-5], which have given place to different iterative methods as the random walk [6-8], first-passage [9], last-passage [10], last-passage Monte Carlo [11;12], etc [6;13-15]. The problem is in that all these methods work for a few very studied geometries and stop doing it when the different geometry. This generates the need to use algorithms that allow to solve of generic form any type of geometry.
The aim of this work is to calculate the capacitance of simple geometries by means of the finite elements method, with the but to see the influence of the edge-effect in the entire capacitance.

The first geometry to study is a unit cube of (length of edge is one meter), with that there is validated the mesh and the loop of calculation.
The second geometry, is formed by two conducting parallel plates of length and thickness are a variable parameters. With this model one tries to justify the employment of the finite elements method to solve the proper singularities of this geometry.

3. Models

The two models are generated with commercial software package ANSYS®.

A. Unit cube model

The unit cube is a typical geometry use to validate the application of the news algorithms at edge effect calculation problem.

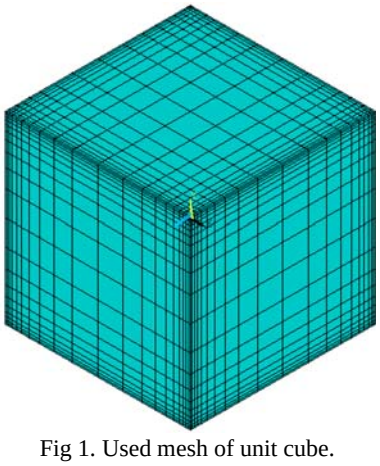

Fig 1. Used mesh of unit cube.

B. Parallel plane plates capacitor model

The parallel plates capacitor is the most popular capacitor employed in the Electrical Engineering field. In this case, the algorithm employed to calculate the total capacitance, take account the variation of the geometrical parameters of the capacitor.

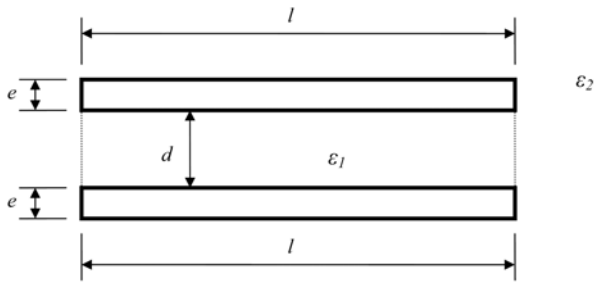

Fig. 2. Two-dimensional model of a plane capacitor.

Where e is the thickness of the conductors, l is the width of the conducting plate, d is the distance between plates, ε_1 is the relative permittivity of the dielectric media placed between the plates and ε_2 is the relative permittivity of the dielectric material that surrounds the system.

4. Results

The obtained results of calculating the capacitance of the unit cube ($0.66067 \cdot 4 \cdot \pi \cdot \varepsilon_0$) compared with those of other authors[9;16-19], show that the used algorithm is valid for the calculation of electrostatics capacitances, also the accuracy in the value of the obtained capacity, she makes to suppose that the criteria of used mesh are correct.
The obtained results of the model formed by the two plane plates, they have been compared with the results obtained by other authors, which has made possible to validate again the model and also to confirmed that the use of an algorithm of calculation based on the finite elements method, it obtains the same results as an custom algorithm and also it offers the flexibility of design, since the used algorithm can be used for any geometry.

5. Conclusion

In this paper it has been demonstrated the validity of FEM to calculate the unit cube capacitance.
The model also includes the volume that surrounds the conductor and take into account the corner and the edge effect of this.
The proposed models based on FEM are not only valid to calculate the capacitance of the unit cube and to obtain the surface charge distributions, as well as the electric field distribution in the volume that surrounds the conductor, but is also valid for any geometric figure thanks to the flexibility of the FEM, which could be a helpful tool for calculation of complex systems which are the most popular problems in the aerospace industry.

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