A Time-Stepping FEA Coupled to a Non-Linear Semiconductor

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***Abstract* ¾ The aim of this work is to present the electric circuit and the Finite Element Method (FEM) coupling using of a non-linear model for the diode. The coupling was accomplished by two different methods: a direct method and an indirect method. In this second case the FEM program was coupled to a Spice-like circuit analysis package.**

Numerical time-stepping simulations of a test-case show that the non-linear model provided satisfactory results.

INTRODUCTION

The Finite Element and Electric Circuit coupling is a well-known method that brought significant improvements to the computation of electromagnetic fields. Among the remarkable achievements one can quote the simulation of semiconductor components such as diode, transistor, thyristor, etc in the numerical analysis. In many cases an on-off switch approaches those components.

This paper presents two implementations of a non-linear model for a diode. In the first one a numerical module with the non-linear function V(I) (1) for the semiconductor was coupled to *Olympos*, the homemade FEM package. In the second case *Olympos* was directly coupled to *HSpice* a Spice-like package for electric circuits analysis, which considers a non-linear model for the diode.

DIODE MODELING

On-Off Model

In the on-off model the diode is considered as a switch as presented in Fig. 1.

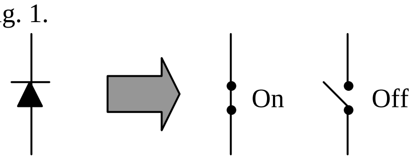
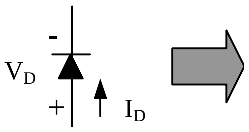


Figure 1: On-Off Model

Non-Linear Model

The non-linear model takes into account the non-linear relation between the voltage and the current in the diode as presented in (1).



$$V_D = V_T \ln\left(\frac{I_D}{I_S}+1\right)+R_S I_D \qquad (1)$$

Where: V_T is the thermodynamic voltage;
I_S is the reverse saturation current;
R_S is the internal resistance.

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NUMERICAL SIMULATION

The problem under analysis is shown in Fig.2.

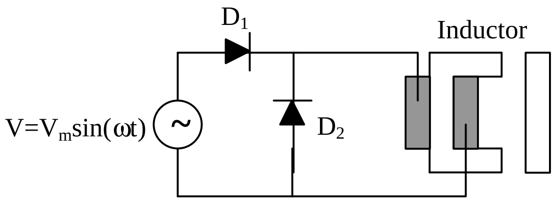

Figure 2: FEM and Circuit Coupling Problem

The inductor is simulated by *Olympos* and it presents an inductance L=13.96 mH and a resistance R=0.17 Ω.

The following analysis were carried out in the problem above:

1. FEM and ON-Off model for D_1 and D_2;
2. FEM and Non-Linear model for D_1 and D_2;
3. HSpice simulation considering L and R mentioned above;
4. HSpice and Olympos (FEM) coupling;
5. Analytical solution considering the On-Off model

RESULTS

Figure 3 presents the results comparison for the current in the inductor for the five analyses mentioned above.

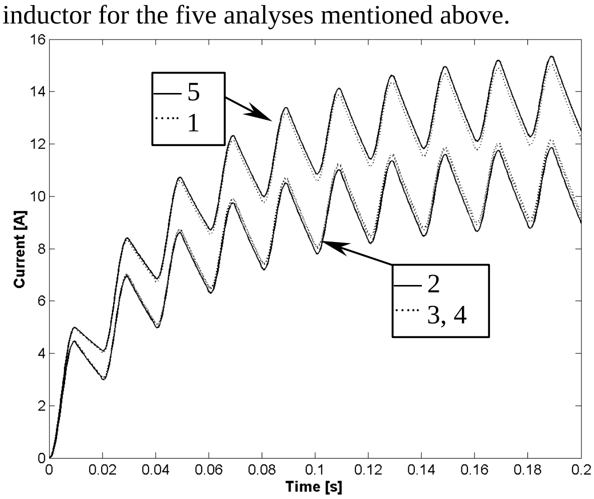

Figure 3: Results Comparison

CONCLUSIONS

Considering the simulation 3 as the reference for the comparisons, one can observe that the On-Off model leaded to a non-satisfactory modeling for the diodes whereas the non-linear model provided a good approach.

Details about the numerical simulations will be presented in the full version of the work.