MODELING OF THE PENETRATION OF AN ELECTROMAGNETIC FIELD INSIDE AN AUTOMOBILE USING A PARALLEL VERSION OF NEC: SIMULATION AND EXPERIMENTAL VALIDATION

A. Rubinstein[1], F. Rachidi[1], B. Reusser[2]

1 École Polytechnique Fédérale de Lausanne, EPFL-LRE, 1015 Lausanne, Suisse
{Abraham.Rubinstein, Farhad.Rachidi,}@epfl.ch
2 Swiss Defence Procurement Agency, Spiez, Switzerland
Beat.Reusser@gr.admin.ch

Abstract - This work presents preliminary results obtained in the frame of the GEMCAR project (Guidelines for Electromagnetic Compatibility modeling for Automotive Requirements). The paper presents experimental results obtained using the VERIFY EMP simulator belonging to the Swiss Defense Procurement Agency. The VERFY simulator generates a vertically polarized electric field with a rise time of 9 ns and a FWHM of 24 ns. The working volume is 4x4x2.5 m3 and the maximal electric field amplitude attains 100 kV/m. A very simplified model of a car (essentially the body shell) and a simple cable harness composed of single wires has been used for testing. Measurements of electric and magnetic fields inside the car as well as induced currents in cables were performed considering two types of illumination, front and side. The experimental results are compared to numerical simulations obtained with a modified version of the Numerical Electromagnetics Code (NEC), which was parallelized using sophisticated numerical techniques especially adapted to modern supercomputer architectures. By using this version of NEC, we have been able to run models consisting of more than 24.000 segments.

1. INTRODUCTION

The paper presents preliminary results obtained as part of the GEMCAR project. GEMCAR (Guidelines for Electromagnetic Compatibility Modeling for Automotive Requirements) is a three-year European project with the aim of producing a freely available guideline for the numerical modeling of automotive electromagnetic compatibility.

The automobile industry has been undergoing an increase in on-board technology. Modern cars exhibit navigation systems, high-tech entertainment devices, and computer-controlled optimization of fuel injection, brakes, etc. As a consequence, the study of the EMC phenomena in automobiles becomes indispensable.

2. PARALLEL NEC

The Numerical Electromagnetics Code is a user-oriented computer code based on the method of moments and written in FORTRAN for the analysis of the electromagnetic response of antennas and other metal structures. It has been widely used for radio communications testing as well as antenna design with great success. With its ability to represent models by means of wires, the code should also allow the simulation of very complex 3D structures.

NEC produces an interaction matrix representing the system of integral equations needed to obtain the currents and fields. The number of elements in this matrix depends on the number of segments and patches that conform the model to be evaluated. This matrix is then reduced using *LU* factorization and, together with the excitation vector, it produces the final solution to the integral equations.

Fig 1. NEC mesh of the car

Because of the complexity of the geometrical information of a car, the original version of NEC is not capable of handling such model. Electrically large structures are impossible to fit in memory and even using the out of core solution, embedded into the code, simulation times and disk spaces attain unpredictable values.

NEC has been optimized and parallelized for this purpose [1]. Using this version of NEC on the Swiss-T1 and Eridan parallel supercomputers belonging to the Swiss Federal Institute of Technology, we've been able to run very complex models of the car containing up to 24.000 segments (see fig. 1).

3. NUMERICAL SIMULATIONS AND COMPARISONS WITH EXPERIMENTAL RESULTS

For experimental testing we used the *VERIFY* (Vertical EMP Radiating Indoor FacilitY, see fig 2), an EMP simulator belonging to the Swiss Defense Procurement Agency. The VERFY simulator generates a vertically polarized electric field with a rise time of 9 ns and a FWHM of 24 ns. The working volume is 4x4x2.5 m3 and the maximal electric field amplitude attains 100 kV/m.

For the initial phase of the GEMCAR project, a simple test case was defined comprising the vehicle bodyshell (without doors or glazing) and a simple harness (single conductor with branches and terminations). Electric and magnetic fields at various points inside the vehicle as well as induced current along the harness were measured.

Fig. 3 presents an example of comparison between measurements and simulations obtained using the developed parallel NEC. It can be seen that the simulations are in reasonably good agreement with experimental data.

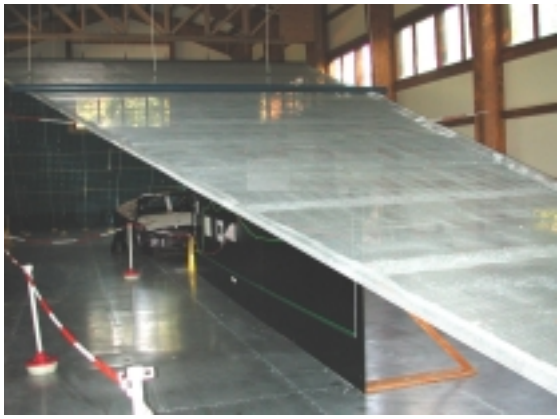

Fig2. The *VERIFY* simulator illuminating the car

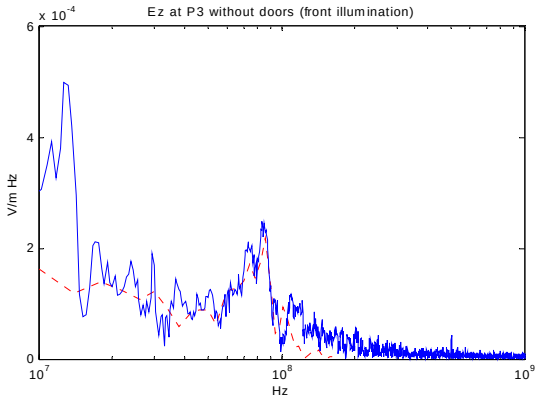

Fig 3. Electric field inside the vehicle. Comparison between simulation (dashed line) and measurement (solid line)

[1] A. Rubinstein, F. Rachidi and M. Rubinstein, "Development of an Optimized Parallel Numerical Electromagnetics Code (NEC) and Its Implementation on the Swiss-T1 and Eridan Parallel Supercomputers", *Annual Review of Progress in Computational Electromagnetics*, Monterey, 18-22 March 2002.