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ELECTROMAGNETIC SHIELDING PROPERTIES DETERMINATION FOR ADVANCED COMPOSITE MATERIALS

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Abstract: *Today, modern technologies and equipments are used in every domain of activity. Some of them use high frequency signals, especially when they are wireless connected. This is why, there is a wide preoccupation to find new materials having electromagnetic shielding properties to ensure their compatibility when functioning. This paper presents some studies in order to determine the shielding capability for advanced composite materials. Knowing the electromagnetic properties for new materials enlarge the possibilities of using them in different applications. The studies are based on experimental determination and Spice simulation*
Keywords: *electromagnetic shielding properties, advanced composite materials, simulations.*

1. INTRODUCTION

Late twentieth century is considered by many experts as age materials. These materials with properties superior to traditional materials programmable entered the top technology fields such as microelectronics, aerospace technology, nuclear technology, medical implants construction technique, but also in the automotive industry, shipbuilding, chemicals, furniture, construction materials industry, sports [1].
The spread of these materials started from the main advantages is that they shows [2]:
- the possibility of "modularization" properties and obtain thus the materials with very different properties,
- have a very good value compared with the materials 'classic', the report tensile strength / specific gravity,
- have a good wear resistance (surface hardness), oxidation and corrosion,
- have a good stability while the size and shape,
- have a good capacity for shock absorption, vibration and noise
-carbon composite materials - carbon or ceramic can be used at high temperatures, up to 2200^0C.

The major advantage, essential properties of composites is the possibility modulation and thus to obtain a wide range of materials whose use can be extended to almost all technical fields.
Making composite materials has become the basis for many technical and economic considerations, among which [1]:
- need for materials with special properties unattainable with traditional materials,
- need to enhance security and reliability in operation of various construction and facilities,
- the need to reduce consumption of scarce materials, precious or precious-consumption,
- can reduce labor and shortening the manufacturing.

2. SHIELDING EFFECTIVENESS DETERMINATION WITH SPICE SIMULATION

The proposed approach consists in a Spice model using transmission line model to simulate the attenuation introduced by a material characterized by the macroscopic parameters ε, μ, σ.
The method has been validated for copper [3], the results obtained being compared with theoretical results published by White [4].

Simulation conditions require that the electromagnetic radiation source be placed at a certain distance from the shield. This simple method enable to obtain a quick shielding effectiveness evaluation for new materials only by knowing their macroscopic properties ε, μ, σ.

The capability of a shield can be expressed using Shielding Effectiveness, that can be computed by the relation (1) [5].

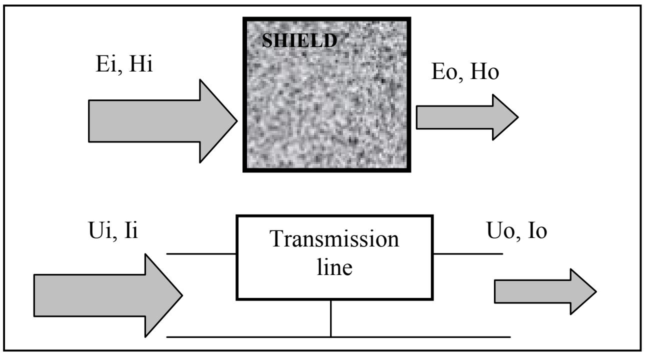


Figure 1: Loss less Transmission line model showing material properties

$$SE_{dB} = 20\,lg\frac{U_i}{U_0} \quad (1)$$

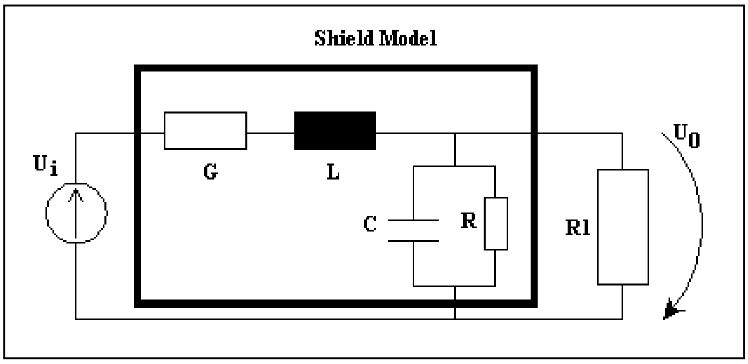


Figure 2: SPICE Model using the transmission line model for the studied material

Layered composite materials have the main advantage the economic one and qualitative reasons, because their use is by saving important quantities of expensive materials or deficient, improving at the same time, the qualities of products and increasing the duration of their operation in conditions of high performance [6].
Composite material structure, reveals itself in the fabrication, electrical characteristics of layers containing components, i.e. electric conductivity σ, the electric permittivity ε and the magnetic permeability μ is represented in Figure 3.

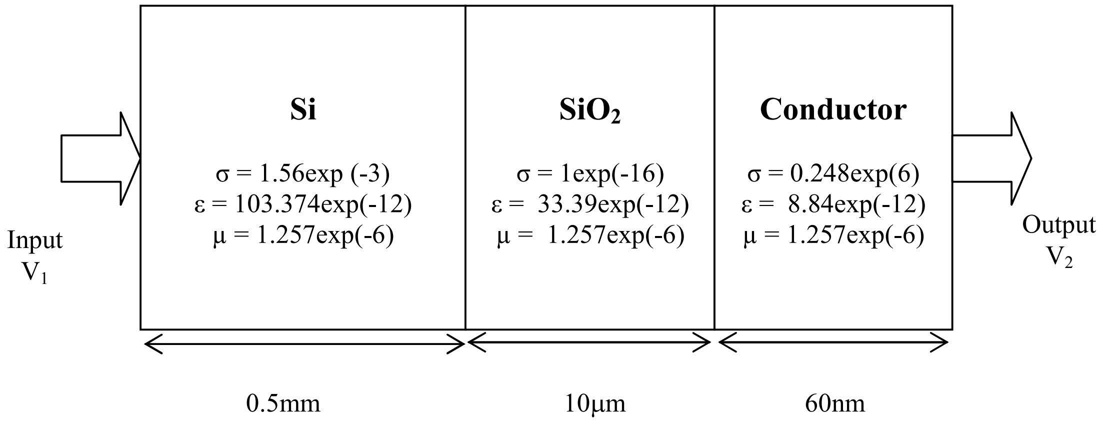


Figure 3: About the composite material construction

For simulation have been used the following model, Figure 4, where T1 is the line transmission model for Si material, T2 is the line transmission model for Si O2 and T3 is the line transmission model for the last conductive layer in the analyzed composite material.

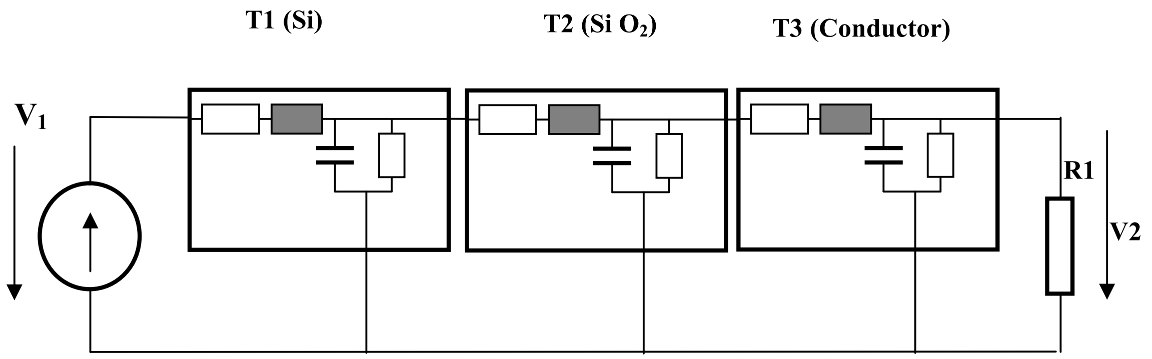


Figure 4: Layered composite material transmission line model

2.1. Spice Simulation results

After the simulation made in the frequency range of 1GHz - 500GHz, Figure 5, it can be seen that till 1GHz the electromagnetic waves attenuation is low, for all frequencies.

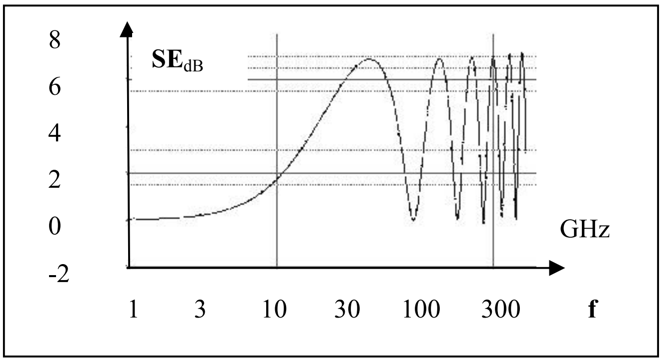


Figure 5: The material attenuation in the frequency range of 1GHz - 500GHz

The results obtained by simulations have compared with experimental determinations at 10GHz. As can be seen in Figure 5, the composite material capability to attenuate the electromagnetic waves, expressed by the shielding effectiveness, is around 2dB and was computed by relation (1) after simulations.
Were made also simulations taking into account only the conductive layer of the composite material. The simulation results are in Figure 6.

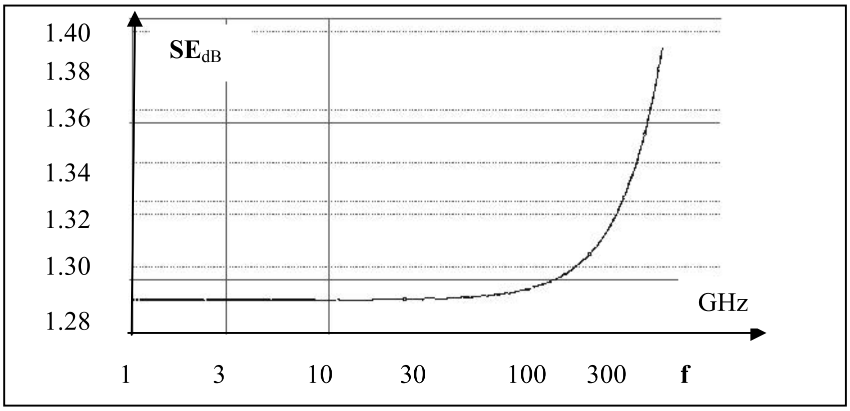


Figure 6: Simulation results taking into account only the conductive layer

Using the transmission line mode it can be studied with Spice Simulation another possible structure for the composite material in order to be used as an electromagnetic shield. Figure 7 shows the characteristic for the shielding effectiveness if the conductive layer thickness would be 60μm instead of 60nm.
It can be seen that even at low frequencies the material has the capability to be used as a shield. At high frequencies the shielding effectiveness is only a little bit higher. The characteristic in the Figure 7 is for a frequency range of 1Hz - 500GHz

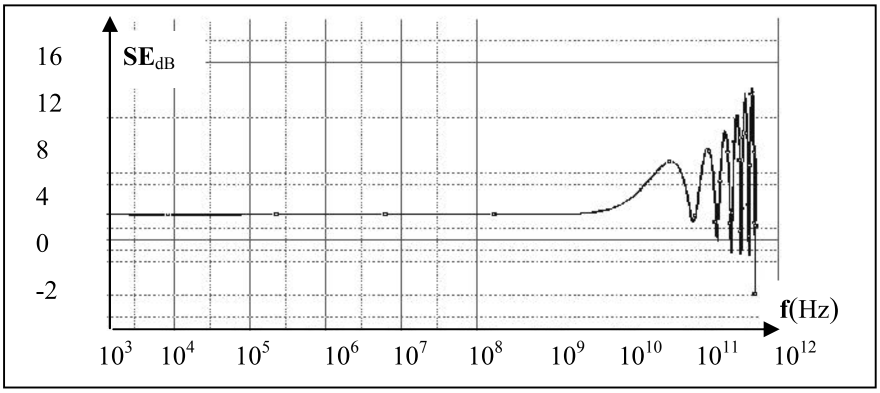


Figure 7: Simulation results taking into account a conductive layer of 60μm

3. SHIELDING EFFECTIVENESS DETERMINATION WITH SIMULINK SIMULATION

Based on the transmission line mode Simulink Simulations have been made for the composite material, Figure 8.

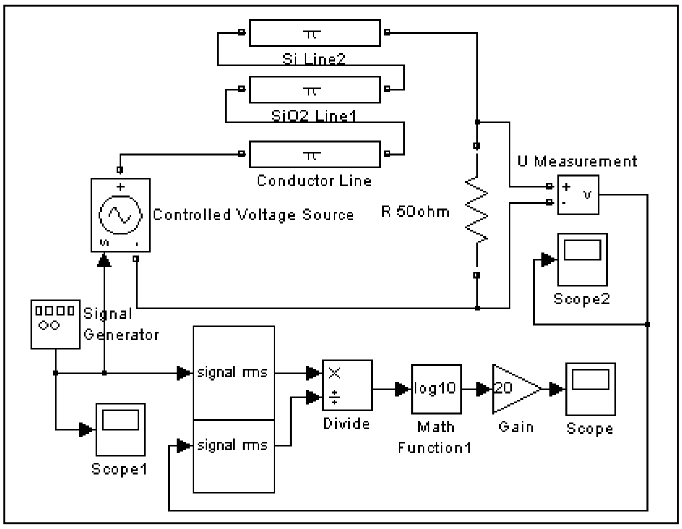
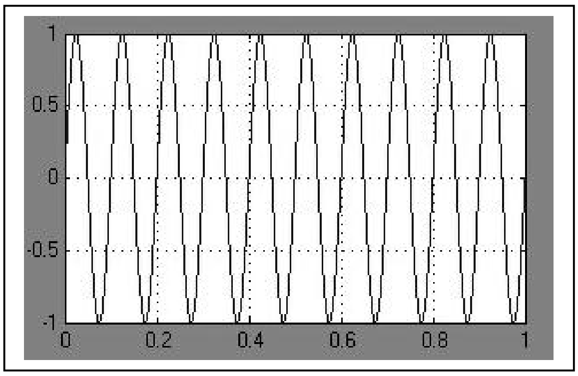
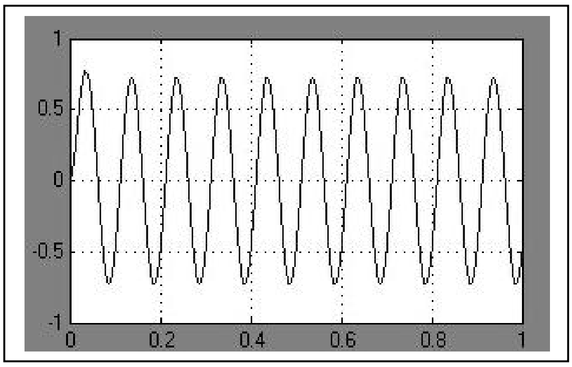


Figure 8: Simulink Simulation Model for advanced composite material

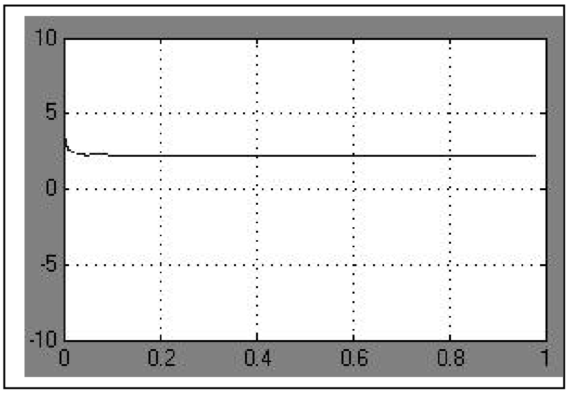
The input signal is applied to a sine 10GHz (same frequency with which the experimental system works).



a.



b.



c.

Figure 9: Simulink Simulation Results

The input signal is shown in Figure 9a, the output signal variation (attenuated), Figure 9b and the shielding effectiveness, Figure 9c), calculated with relation (1).

By comparing the simulation results obtained with different programs it can be seen that the attenuation introduced by the composite material at a frequency of 10GHz are in the range of (1.5dB-3dB).

To verify the correctness, simulation for the conductive layer have been made. The constant attenuation (excepting the first moments) obtained, as in Figure 10, according to the theory, shows the accuracy of the simulations

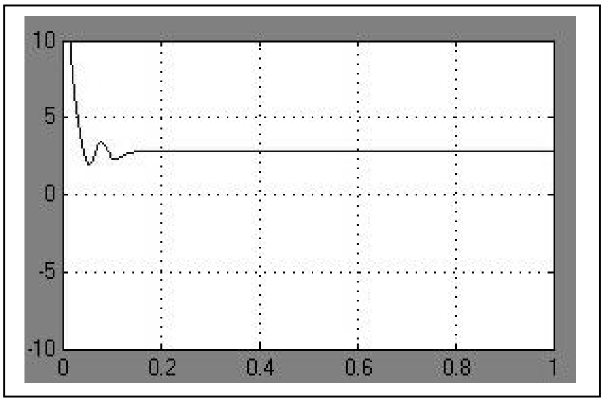


Figure 10: Simulink Simulation Results for conductive layer

Spice simulation programs and Simulink (in the Matlab R2007b) warns of the possibility of rolling over a larger calculation errors due to very low values of line capacity and inductivity.

4. EXPERIMENTAL RESULTS

For the composite material attenuation measuring in the field of radiofrequencies, was used the substitution method, known to be of high precision. Measuring scheme is given in Figure 11. For experimental determinations was used a wave guide system with an Gunn oscillator at a frequency of 10 GHz, as stated above. The result obtained through the mediation of several determinations is around SE_{dB} = 3dB. Comparing the value obtained with the simulations at the same frequency SE_{dB}= (1.5dB-3dB, it reveals a good precision, which means that the simulations made for the composite material are correctly made.

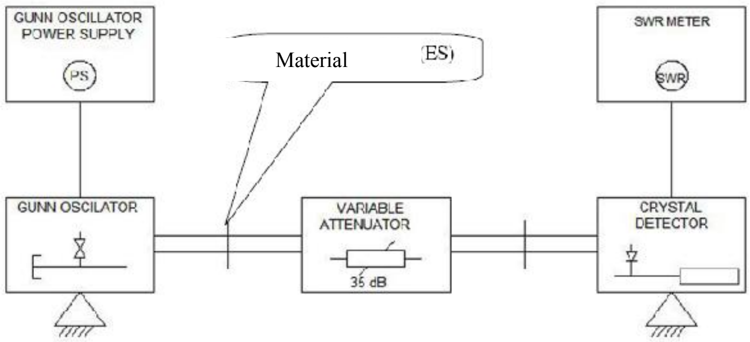


Figure 11. Schema bloc pentru determinarile experimentale

5. CONCLUSION

This paper proposes the use of a method of determining the shielding capacity of the electromagnetic waves composite material. Considering their many uses, knowledge of electrical characteristics of attenuation of electromagnetic waves is important.
The future can book big surprises on the border areas where composite materials will be used, and the current trend of expanding mobile communications and data transmission will be connected with them.
In addition, the simple method of simulation presented in this paper offers to the manufacturer the possibility to pre-choose the dimensions and the combination of materials in order to get superior performance of the composite material.

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