Electromagnetic Shielding System for Information and Communication Equipments

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Abstract **- Today, most of the human activities are computer-controlled with respect to equipments and platforms functionality, quality of the process and people and goods safety. Unlike the specialized platforms, where this feature is already implemented and developed according to the system architecture, in many other applications this function can be achieved by including a simple desktop or laptop and the specific software application in the platform original configuration. These applications can be also very sensitive, in terms of safety, quality and costs, so the whole controlling process must be accurate, stable and robust. One of the main problems that can occur and affect these systems workability is represented by electromagnetic interference (EMI) presence and the complementary issues, especially when the scenario takes place in a hard electromagnetic environment (industrial, military, IT&COM high-density areas etc.). There are some technical approaches to solve this inconvenience, but most are focused to adapt the current equipment configuration, which was intended to work in a specific environment and to provide specific features, to the new place working requirements. Our solution is to develop a self-independent EMI protection system that can be easily adapted to a large range of the IT&COM equipments in order to minimize costs, product performances distortion and overall time implementation.**

Keywords: *EMC, shielding, Electromagnetic compatibility, EMI*

I. INTRODUCTION TO ELECTROMAGNETIC SHIELDING

Electromagnetic shielding and filtering represent the most common solutions used for equipments EMI/EMF protection, consisting of special materials and devices integrated into the original system configuration, through different implementation methods.

Electromagnetic shielding main application is to reduce the levels of electromagnetic fields radiated by the intrinsic equipment EMF sources or to protect [3] the equipment against external interferences in order to immunize it and provide a controlled EMF environment.

The electromagnetic emissions of equipments represent a natural consequence of their operation, a phenomenon that can be reduced or amplified depending on many factors, often difficult to be estimated by electrical and electronic equipment manufacturers.

The classical solution considered by most manufacturers of electromagnetic protected equipments / systems consists in the construction of new enclosures for equipments, use of shielded [1], [4], [6], [7], [8] cables, and external / internal power supply filtering circuits. Regardless of the implementation, in the absence of a specialized laboratory able to measure the quality of the solution used, it is difficult to quantify SE using only analytical calculation methods, since there are phenomena which can be difficult to predict, such as:

a. diffusion waves through the wall screen,
b. couplings by accessing screen conductors,
c. the penetration aperture.

Despite these drawbacks, analytical calculation may still be considered for a base estimation of the shielding performance specific to a particular solution.

In the case of high electric conductivity materials (which is the most common situation), the diffusion phenomenon hasn't a significant weight when in the conductors are present couplings and / or penetration through the apertures. The exception is the region of low frequency and the magnetic field radiation.

Couplings by conductors who access the screen have a significant share in the total field radiated but are significantly less dependent on the design of shielding, but are influenced more by the embodiment of filtrations and joints bonding (welding) of the access points in the outer shielding cables.

II. SHIELDING EFFECTIVENESS CALCULUS

Regardless design and realization, the electromagnetic shielding solutions are measured by shielding effectiveness - SE (Shielding Effectiveness) parameter. Additionally it can be also considered other criteria for assessing the technical solution, namely ergonomics, reliability, modularity, implementation costs etc...

Furthermore, knowing the screening material, we can estimate the value of SE. In theory, if it's considered a simplified case of a plane wave passing [2] through an infinitely long screen, then it is possible to define the following components of shielding effectiveness: absorption, reflection and multiple scintillations attenuation.

In figure 1 there is represented the simplified model of electromagnetic shielding. As we mentioned above there are figured the main components of shielding with respect to the radiation source and material design and properties.

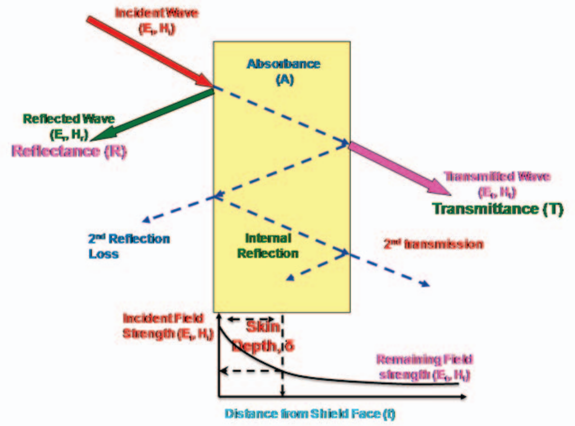

Fig.1 Microwave absorption [8] and EMI shielding behavior

If there is considered the case of plane wave radiated by a dipole or a winding looped at distance r, corresponding to far field condition ($r\rangle\rangle\lambda/2\pi$), the sizes of shielding components (in dB) are respectively:

$$A\langle dB\rangle = 3{,}34\cdot\sqrt{\mu\cdot\sigma\cdot f\cdot d} \qquad (1)$$

$$R\langle dB\rangle = 168 - 20\cdot\log_{10}\left(\sqrt{\frac{\mu\cdot f}{\sigma}}\right) \qquad (2)$$

$$R_r = 20\cdot\log_{10}\left\{1-10^{-\left(\frac{A}{10}\right)}\cdot\left[\cos(0{,}23\cdot A) - j\cdot\sin(0{,}23\cdot A)\right]\right\} \qquad (3)$$

and $R_r = 0$ if $A > 15\ dB$;

where:

A - attenuation by absorption,

R - attenuation by reflection,

Rr - mitigation by internal reflections in the material,

f - wave frequency,

μ - magnetic permeability of the material,

σ - electrical conductivity of the material.

To characterize a screen size using electromagnetic shielding effectiveness called, SE, defined as the ratio of the field strength (electric or magnetic) measured in the absence of the screen (Es) and with the screen (E_0) we can use:

$$SE = 20\cdot\log_{10}\left(\frac{E_s}{E_0}\right)\quad\langle dB\rangle \qquad (4)$$

or by expression of powers:

$$SE = 10\cdot\log_{10}\left(\frac{P_i}{P_t}\right) \qquad (5)$$

If the attenuation A, R and R_r are expressed in dB, by summing the quantities of the components of the shielding, then we obtain:

$$SE = A + R + R_r \qquad (6)$$

The main factors influencing the SE are:

- frequency field;
- material type and thickness;
- screen geometry (rectangular, cylindrical, spherical, etc.);

III. NUMERICAL METHODS USED FOR ELECTROMAGNETIC SHIELDING CALCULUS

Full description of macroscopic magnetism phenomena is performed using Maxwell's equations (considered as postulated), equations describing the behavior of space-time field. Maxwell's equations can be presented and used in two forms: differential (local) or integral (global).

In the case of stationary environments, the most important difference between the two forms of Maxwell's equations lies in the treatment of discontinuities of the materials and / or sources.

The most common methods for calculating numerical electromagnetism problems are: method of moments (MoM), the method of transmission line modeling (TLM), finite element method (FEM) and finite difference method (FDM - with different variations and sub- options). Not all of these methods are the same in terms of the accuracy of the results of the processing time and computing resources required to be used by each of them.

IV. SOFTWARE MODELING AND SIMULATION

In our case study we conducted researches in order to optimize the electromagnetic protection system design, in order to be used for EMF reduction generated by a standard PC. Protection system modeling and simulation were performed within ANSYS HFSS software, in the 10 MHz - 9 GHz frequency band.

The conducted analyzes allowed us to establish the constructive details of the shielded enclosure, taking into account the electromagnetic protection requirements established for the whole system.

In order to find more accurate, reliable and fast solutions to our problem we decided to start our work by simulating a simplified model of the electromagnetic protection system, considering it a rectangular single material enclosure. We had the opportunity to conduct many parametrical analysis in order to take a final decision regarding system design.

In this respect, simulations were performed for:

a. Study regarding the influence of apertures shapes on the overall system electromagnetic shielding performance;

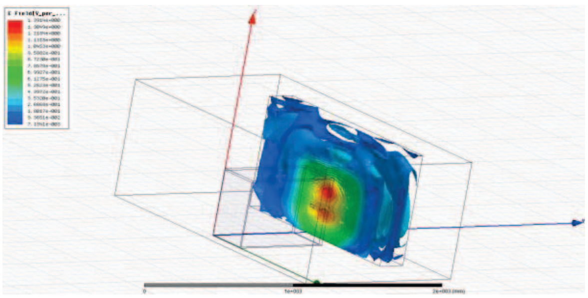

Fig. 2 Electric field distribution in rear of the shielded enclosure with rectangular gaskets at 1 GHz

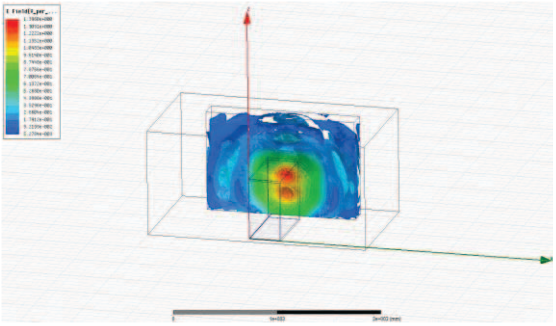

Fig. 3 Electric field distribution in rear of the shielded enclosure with circular gaskets at 1 GHz

The above simulations revealed the influence of an aperture on overall shielding performance, and underlined the idea that we must specific connectors for data input/output interfaces.

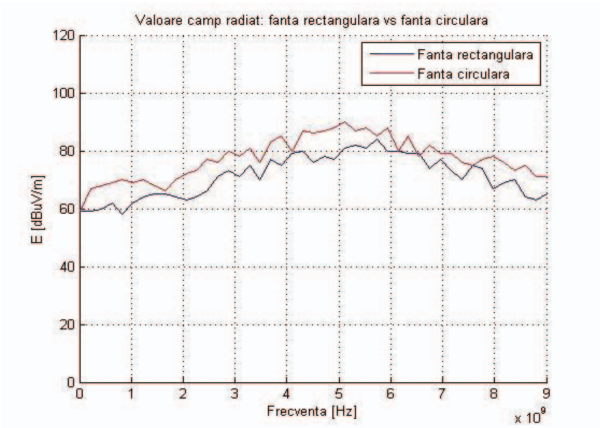

Fig.4 Electric field radiated at 1 GHz rectangular gaskets vs circular gaskets

b. The optimization of the I/O connector panel position, on the rear panel;

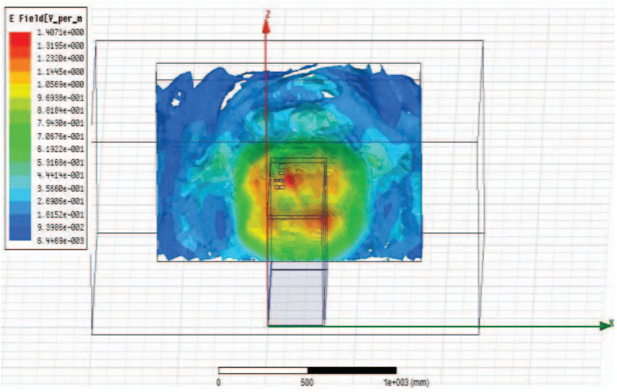

Fig.5 Electric field distribution in rear of the shielded enclosure with top lateral position of connectors panel at 1 GHz

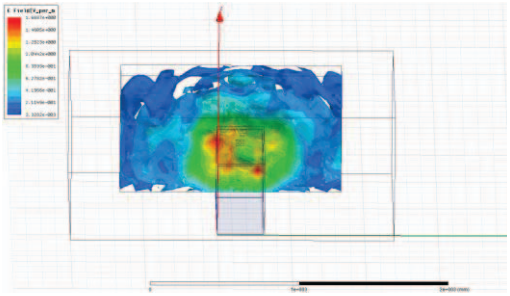

Fig.6 Electric field distribution in rear of the shielded enclosure with central position of connectors panel at 1 GHz

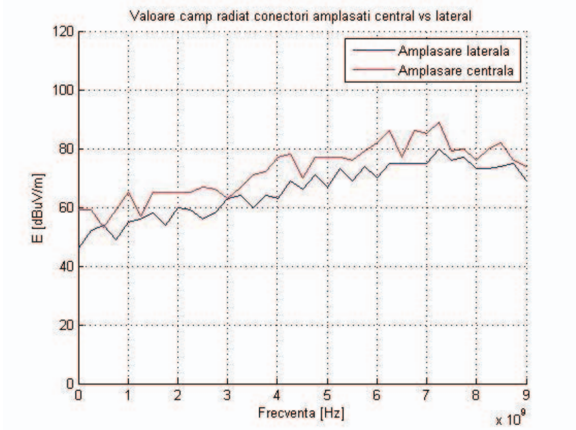

Fig.7 Electric field radiated at 1 GHz central position panel vs lateral position panel

The obtained results helped us to “fit” the connector panel in the “right” position, considering the above stated objectives.

c. The optimization of the filter vent Panel position, on the rear/side panels;

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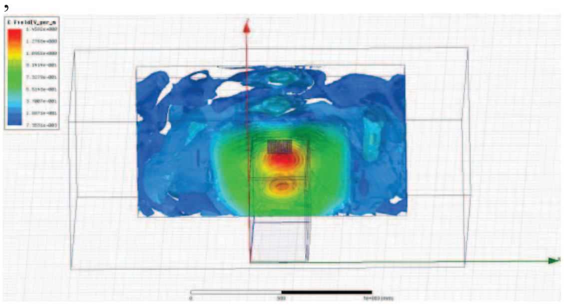

Fig.8 Electric field distribution in rear of the shielded enclosure with top lateral position of filter vent at 1 GHz

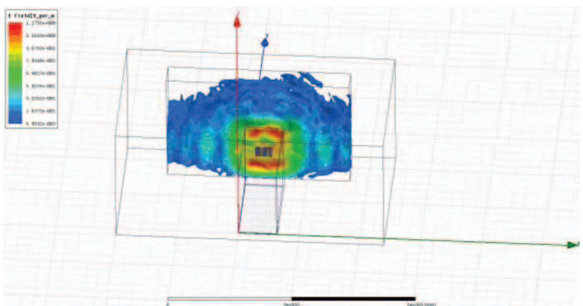

Fig.9 Electric field distribution in rear of the shielded enclosure with top central position of filter vent at 1 GHz

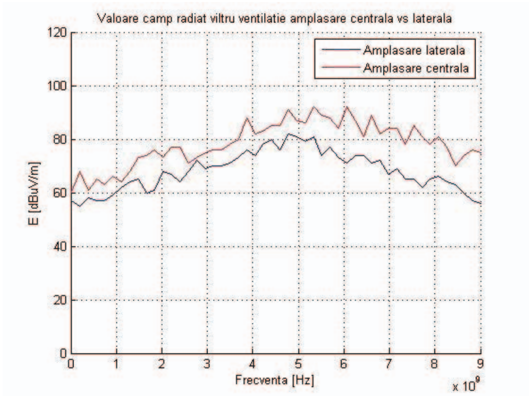

Fig.10 Electric field radiated at 1 GHz
top central position vs top lateral position panel

As well as the previous study the obtained results allowed us to find the best solution for air filter position.

V. Conclusions

There are many aspects to be taken into account during the system design and realization phases, especially those related to constructive details and materials type.

Simulations have led to specific conclusions about how to achieve a shielded enclosure. There were also other factors that contributed to our final decision regarding system design and realization, like technologies and materials availability, implementation costs, ergonomics and reliability. Other good practices were taken into account, like EMI gaskets or shielded cables usage.

The main scientific objective of our project was to develop a modular and versatile electromagnetic protection system that could "fit" different types of informatics systems.

The conducted research activities allowed us to find an optimal solution for system design, taking advantage of powerful simulation software and testing infrastructure availability. There is known that a shielded enclosure could be improved if better and larger materials are used, but in particular case there is possible to improve the overall system performance by elements repositioning or replacement.

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