EXTENDED ABSTRACT

Simulation and Analysis of High Frequency Electromagnetic Interference in Power Supplies Using Hybrid TLM and MoM Method

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Abstract — Electromagnetic compatibility (EMC) needs a lot of considerations in either design and packaging of electronic products. Electromagnetic interference and compatibility of metallic enclosures in high voltage industrial power supplies have been studies here. The high power supplies need apertures all over their body, so a lot of EMC cares has to be done. The aperture size and position effect on electromagnetic parameters such as electric field intensity, shielding effectiveness, return loss, and resonant modes have been studied. This study is done using a novel hybrid simulation method with TLM modeling in near field and Method of Moment in far field.

I. INTRODUCTION

Electromagnetic shielding has been widely used to reduce the unwanted radiations from the electrical equipment and also increase the immunity of circuits and systems against any harmful external emission.

The ability of a typical shielding to perform any of these missions can be measured by a parameter named Shielding Effectiveness (SE), defines as the proportion of the electric field intensity in presence of the shield to a situation where it isn't. This definition of SE is completely depends on the box shape and the location and size of the apertures.

As a result of the strict EMC legislations and regulations, an effective analysis of the SE parameter is very important. In this regard, two comprehensive methods are suggested and used which are analytical and numerical methods.

The analytical methods [1] are very fast estimation tools which try to simplify any given structure to achieve a specified precision. So these methods are not suitable for complicated geometrical structures.

On the other hand, numerical methods such as Finite Difference Time Domain (FDTD) [2], Method of Moments (MoM) [3], and Finite Element Method are used to simulate geometries with any desired complexity and extract the SE parameter.

Another numerical technique which is used to evaluate EMC problems is Transmission Line Modeling (TLM) method [4]. The major characteristic of the TLM method is its ability to model any geometry with any material property. It is also capable of calculating the results in any given range of frequencies.

Comparison between different numerical methods has been made in many recent works. In [5] the FDTD method was compared with MoM in shielding evaluation of a typical EMC problem. On the other hand, Sewell [6] made a comparison between experimental, analytical, and TLM methods.

In this paper a combination between TLM and MoM methods will be introduced to evaluate the high frequency electromagnetic interference. Then this newly defined hybrid method would be used to calculate the SE parameter of cubic enclosures which are used as shielding structures in power supply equipments.

II. THEORY

Analysis of electromagnetic problems in complicated environments like areas with complex structures or non-homogeneous materials is very difficult. The flexible nature of numerical methods like TLM made them suitable to analyze this kind of environment by discrete them into separate elements named mesh [7, 8].

The weakness of these numerical methods is in the simulation of free space radiations, as the meshing the free space requires infinite number of memory and time resources.

Methods with integral equation basis like MoM are useful in simulation of free space radiation. Despite the fact that this method cannot utilize in any desired geometry [9], this paper used it in conjunction with a flexible method like TLM. So the discrete behavior of TLM has been used beside the free space modeling behavior of MoM in the same time.

In this proposed hybrid method, any given electromagnetic structure will be surrounded in a hypothetical sub domain as shown in figure 1. Two distinct analyses would be done inside and outside the area.

The tangent electric and magnetic fields intensities are the only conjunction between the areas inside and outside of the hypothetic sub domain. These tangent field intensities are used in the free space green function to calculate any desired far field radiation.

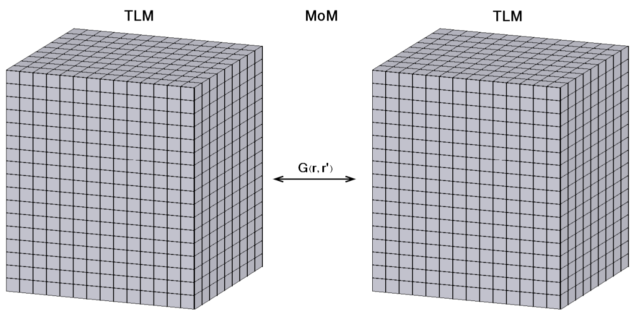

Figure 1: Definition of the hypothetical sub domains in the proposed hybrid simulation

III. RESULTS

The electromagnetic plane wave coupled inside a shielding box through an aperture will be evaluated using figure 2. This figure presents a typical power supply. In this figure a coaxial cable with radius of 50mm and length of 900mm is placed inside the box.

The electric field intensity which has been coupled inside the box of figure 2 has been plotted in figure 3. This figure is plotted both in presence of the cable and when the cable is removed. Presence of the cable causes movement of and also increases the number of resonant frequencies. This effect is more obvious in lower frequencies.

In figure 4 the SE parameter of the vertical component of the electric field (for the enclosure of figure 2) has been plotted. The aperture size is supposed to be 300*300mm. same results could be achieved using magnetic field intensity. As can be see, the first resonant frequency occurs in 210MHz which coincides with the $f_{(110)}$ resonant mode. The second and third resonant modes are $f_{(111)}$=227MHz and $f_{(120)}$=335MHz.

Effects of the electromagnetic waves which are radiated from inside of the box are considered here. Figure 5 presents this problem. The exciting coaxial cable has inner radius of 0.2cm and outer radius of 5cm. the coaxial cable has been math loaded to the ground to boost the frequency bandwidth of the radiated field.

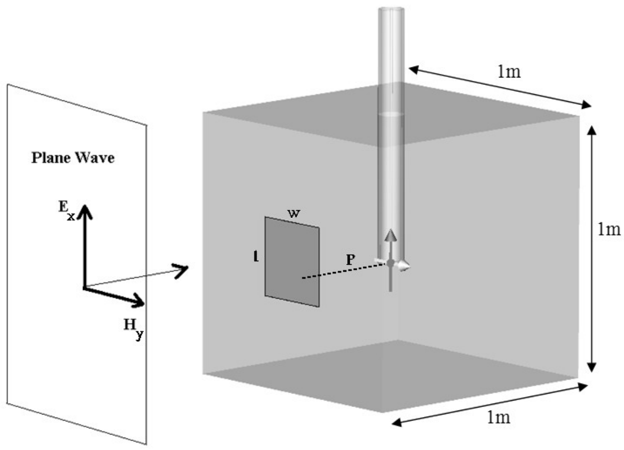

Figure 2: Typical shielding enclosure including an aperture

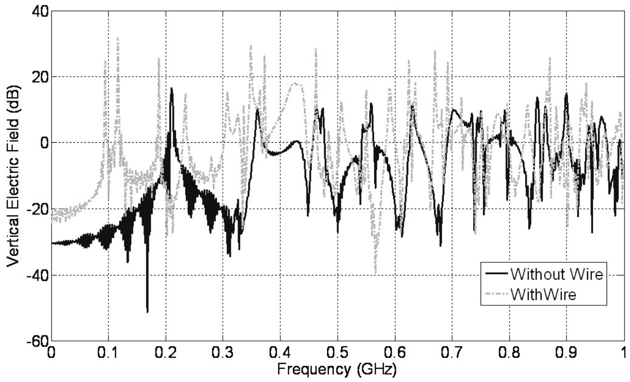

Figure 3: Electric field intensity coupled inside the box with and without the coaxial cable

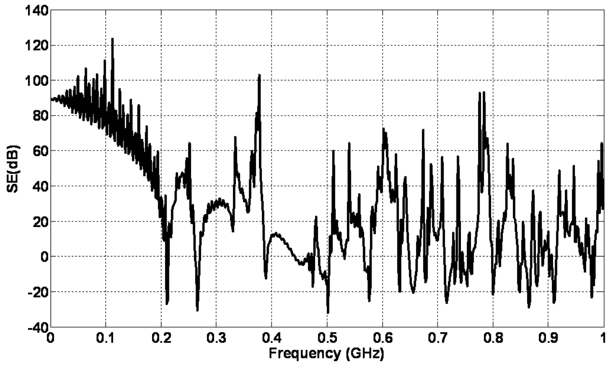

Figure 4: SE parameter of the enclosure with one aperture

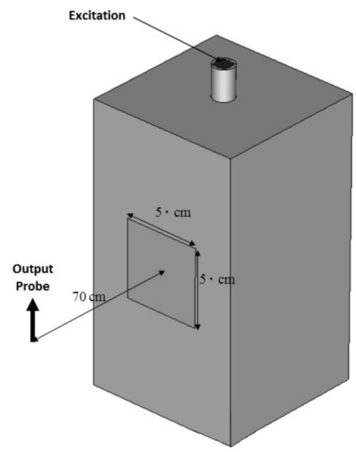

Figure 5: Electromagnetic interference from the box

Return loss of the feeding coaxial cable is plotted in figure 6. Resonant frequencies with lower return losses are classified in 3 categories. 1) cavity resonant frequencies, 2) aperture resonant frequencies, and 3) aperture-cavity resonant frequencies. Resonant frequencies of the cavity are presented in table 1.

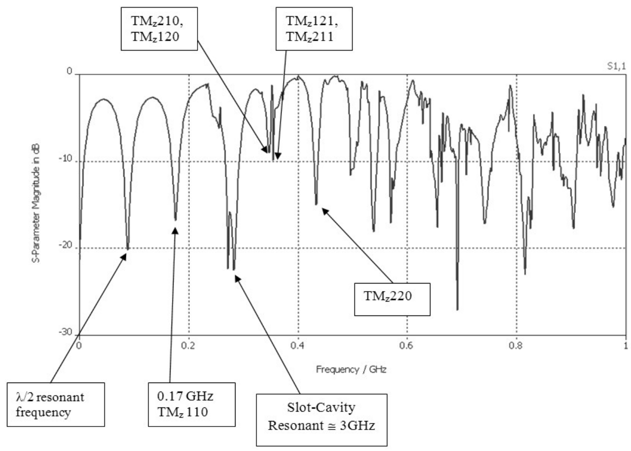

Figure 6: Return loss of the input coaxial cable

Table 1: Resonant frequency of the excited modes inside the box

Mode Number	Resonant Frequency [GHz]
TM 110	0.176
TM 210 and TMz 120	0.335
TM 211 and TMz 121	0.345
TM 220	0.42

IV. REFERENCES

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