

Simulation of Shielding Characteristic of a Typical Decay Waveguide Window for EMP

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Abstract –This work simulates the shielding characteristic of a typical decay waveguide window for EMP. In the past, most researchers on electromagnetic protection have mainly focused their attention on the aperture coupling on the rectangular cavity. In contrast, the focus of this paper is not on it, but rather on the shielding characteristic of a typical decay waveguide window for EMP. The effect on EM coupling and shielding due to penetration through apertures behind it is also investigated. Here, the popular double exponential pulse has been used in the simulation of incident EMP. Full wave method of finite integration has been employed for the field strength at different points behind the window decay waveguide window. In addition, field nephograms are obtained for showing the whole shielding characteristic. Finally, the simulated results are verified with test data

1 INTRODUCTION

Shielding is a fundamental step in establishing or improving the electromagnetic compatibility of active and of passive devices [1-2]. There are many kinds of protection devices in the field of electromagnetic shielding. Among them, decay waveguide window is very common components in shielding applications [3]. The visibility of displays or status lamps and leds is needed but is often accompanied by the introduction of a discontinuity in the shield, with the consequent detriment of performance. Decay waveguide window is an effective way to reduce such performance degradation and are usually applied through a gasket on their contour, although other techniques are also available, such as those based on permanent soldering or welding.

Nowadays, there are many papers on aperture coupling on the rectangular cavity [4]. However, little work has been done in aiming at the shield simulation on decay waveguide window.

Therefore, the focus of this paper is on the simulation of shielding characteristic of a typical decay waveguide window for EMP. In contrast to the traditional sine wave, the EMP can not only contain more information, but also be close to the natural protection scene.

This paper has been structured as follows. First, we give a detailed description of the problem, including the geometrical model and the excitation and solution, the solution algorithm are presented in

Section 2. This is followed in Section 3 by the CST simulation that provides the results on shielding characteristic, including distribution of electromagnetic field and tested data in Section 3. Finally, some conclusions are discussed in Section 4.

2 SIMULATION PROCESS

2.1 Geometry Description

Fig. 1 shows the geometry of a decay waveguide window with a square outer frame. Here, the green dotted lines indicate the rectangular axis.

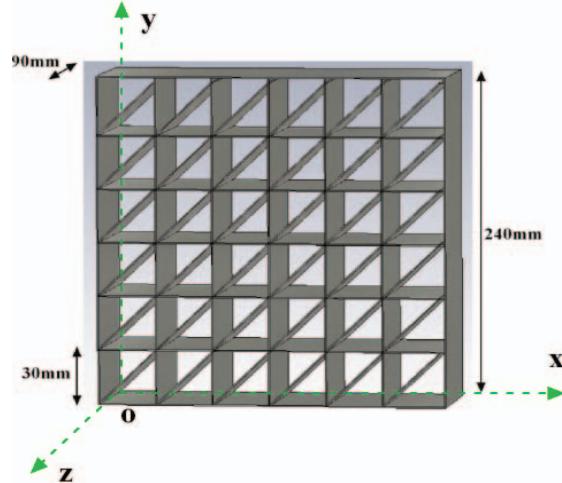


Figure 1 Geometry of the typical decay waveguide window.

2.2 Excitation and Solution

Here, the popular double exponential pulse has been used in the simulation of incident EMP. Generally, its shape is given by (1) as [5]

$$E(t) = E_0 k (e^{-\alpha t} - e^{-\beta t}) \quad (1)$$

where $E_0=5.0*10^4$ V/m is the maximum of the function, $k=1.05$ is a modifying factor, α and β are characteristic parameters, $0 < \alpha < \beta$ to keep the pulse positive polarity, and $t \geq 0$ for t (in seconds) denotes physically the time (as shown in Fig. 2). Usually,

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99.8% of the energy lies in 10^3 - 10^8 Hz. In addition, the incident direction is normal to the outer plane of decay waveguide window, while the polarized direction is along the x axis.

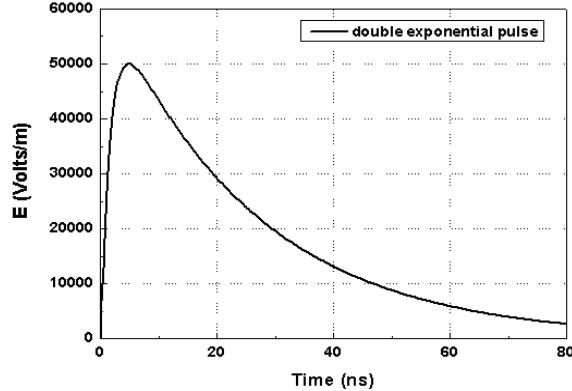


Figure 2 Double exponential pulse shape.

2.3 Algorithm

CST MWS, which adopted finite integral time-domain technique (FITD) proposed by Weiland in 1976, was used as the main simulation tool [6]. In combination of the perfect boundary approximation (PBA) and thin sheet technique (TST), significant improvement in geometry approximation with computation speed is achieved yielding highly accurate results. Non-uniform meshing scheme was adopted so that major computation effort was devoted to regions along the inhomogeneous boundaries for fast and accurate analysis.

A total of 15625 mesh cells were generated for the complete model as shown in Fig 3, and the simulation time was 121 seconds (including mesh generation) for each run on an Intel CoreTM2 Duo E7200 2.53 GHz CPU with 2 GB RAM system.

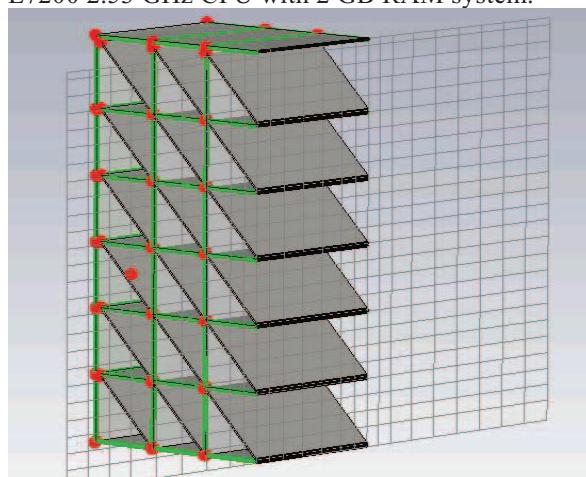


Figure 3 Mesh section and control points of the typical decay waveguide window.

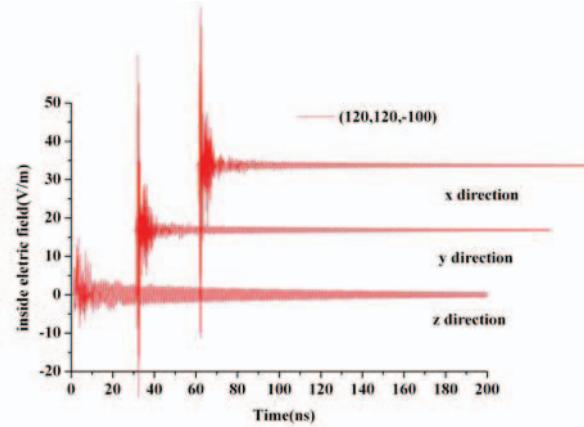


Figure 4 Components of electric field in time domain behind the window center related to the x, y, z axes with center coordinates (120, 120, -100).

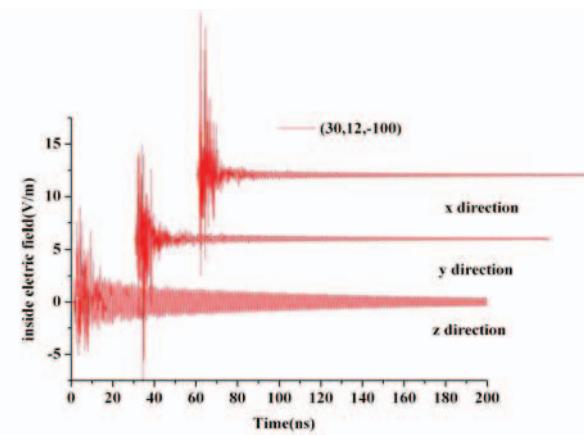


Figure 5 Components of electric field in time domain behind the window related to the x, y, z axes with edge coordinates (30, 12, -100).

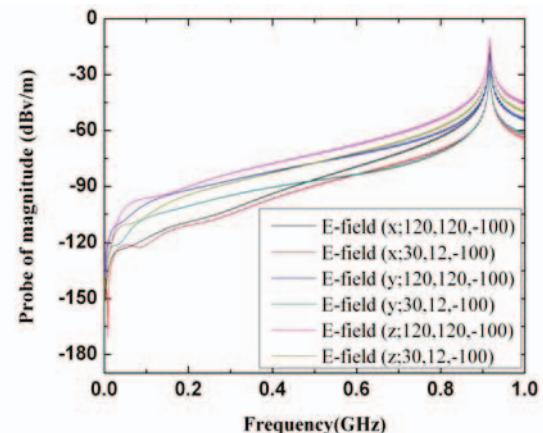


Figure 6 Frequency domain curves of all observation points.

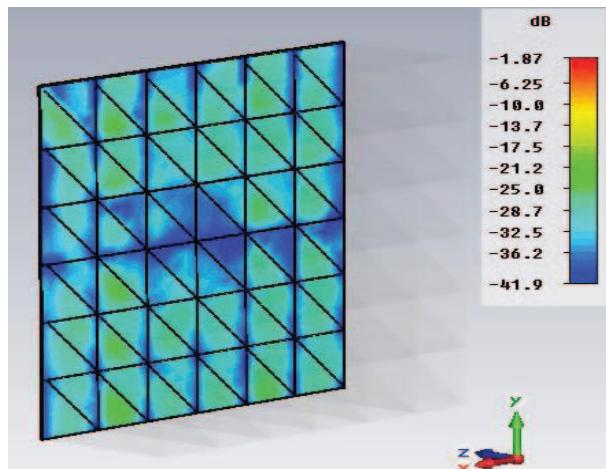


Figure 7 Distribution of electrical field front the window center.

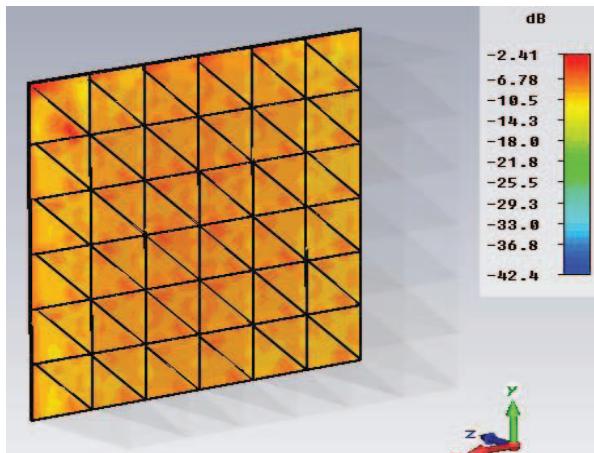


Figure 10 Distribution of magnetic field front the window center.

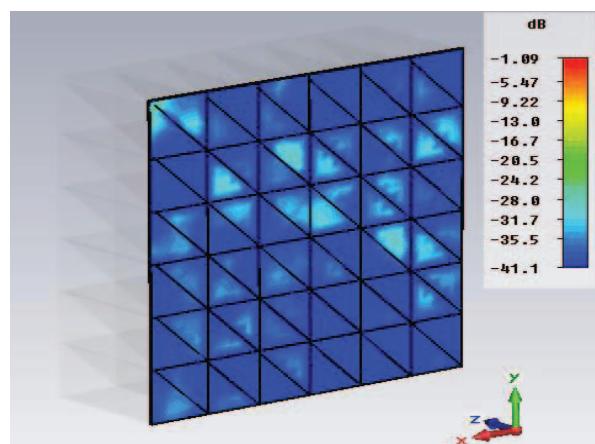


Figure 8 Distribution of electrical field behind the window center.

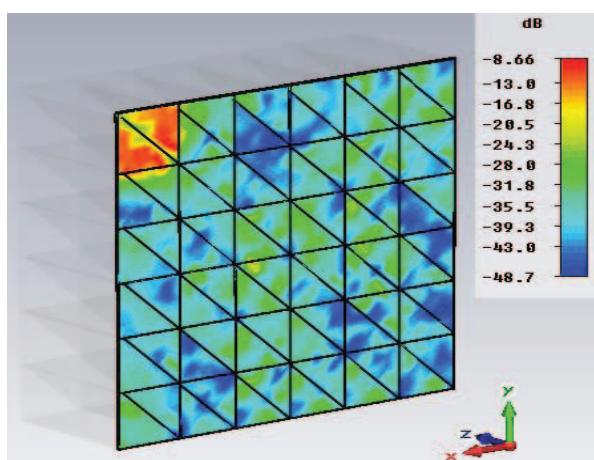


Figure 11 Distribution of magnetic field behind the window center.

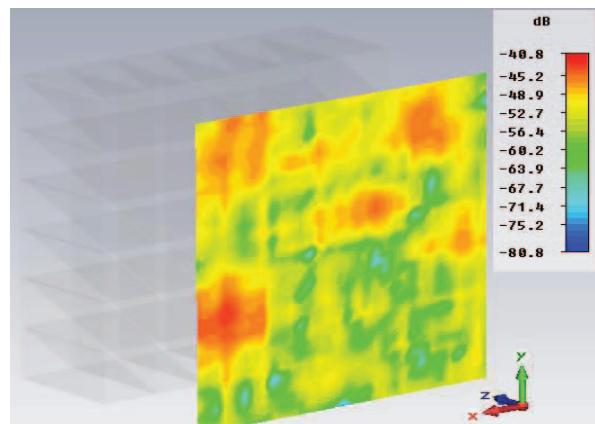


Figure 9 Distribution of electrical field behind the window center 10cm.

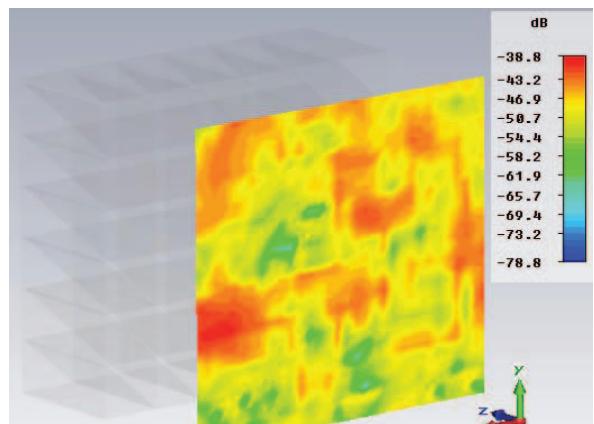


Figure 12 Distribution of magnetic field behind the window center 10cm.



Figure 13 Photo of GTEM cell.

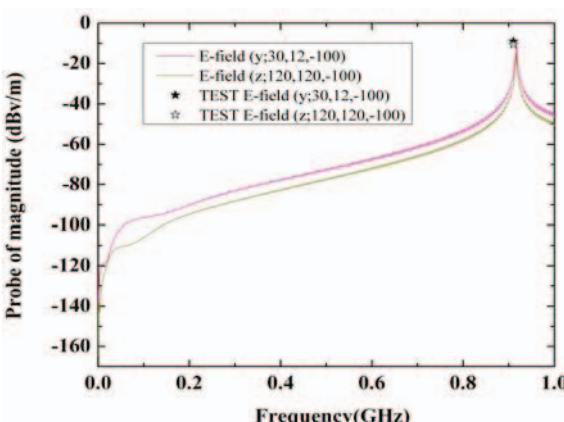


Figure 14 Data comparison between from GTEM cell and simulation.

3 RESULTS AND ANALYSIS

In this section, simulation results obtained with the FITD are presented. Fig. 4 and Fig. 5 presents results of the components of electric field in time domain behind the window center related to the x, y, z axes with center coordinates (120,120,-100) and edge coordinates (30, 12,-100), respectively. From these figures, it is obvious that their attenuation trends are similar to each other. In addition, the initial amplitudes of center coordinates are larger than those of edge coordinates. What's more, according to the frequency domain curves from Fig. 6, we found that their resonant frequencies are close to 0.9GHz which corresponds to the main mode of the decay waveguide. Then, we can see the distribution of electrical fields and magnetic fields front and behind the window center and behind the window center 10cm in Fig. 7 to Fig. 12. The amplitudes of electrical and magnetic fields decrease with the

increase of the distance between observation plane and xoy plane. Among these, the distribution of magnetic field behind the window center has a little difference in the bottom left-hand corner. It may be the embodiment of edge effect. Finally, we have made experiments to verify these results by GTEM cell (as shown in Fig. 13). As a result, Fig. 14 shows they agree well. We only give the test results correspond to the resonant frequency so as to simplify the analysis.

4 CONCLUSION

In this contribution, the simulation of shielding characteristic of a typical decay waveguide window for EMP was investigated. In addition, the EM coupling fields and shielding curve behind apertures is also presented. Moreover, the finite integral time-domain technique was successfully applied to the simulation, with the popular double exponential pulse. As a result, we have found the resonant frequency corresponds to the main mode of the waveguide. We believe these results will benefit the electromagnetic shield design, especially in decay waveguide window. Future work to be performed will include a full study of shielding characteristic of the cylinder decay waveguide window.

References

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