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Analysis of Modeling and Simulation on Shielding Effectiveness

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Abstract. Enclosure is an important equipment to reduce the electromagnetic interference. Rational design can make electronic equipment has a good electromagnetic compatibility. This paper presents the coupling elements of the typical electronic information equipment, then uses the HFSS scripting language (VB script) to build a parametric, universal simulation model for the enclosures with apertures, and develops a visual simulation software with the VC++ 6.0, at last gets an automatic modeling and simulation platform. Using the visualization simulation platform, we analyzes the shielding effectiveness of a typical enclosure. Comparing the simulation results with test values, we verify the validity of the software and the model. Finally the different apertures of enclosures are analyzed, and we get a general conclusion to guide the design of enclosures.

1. Introduction

With the rapid development of electronic information technology, the operation speed of equipment continues to increase, frequency band also becomes wider, transmission power is also growing, and the equipment is increasingly vulnerable to electromagnetic interference. Meanwhile, the environment of electronic devices is complex. In order to achieve electromagnetic compatibility (EMC) of electronic systems, the electronic devices not only need to suppress interference caused by themselves, but also need to prevent external electromagnetic environment effects on them. Therefore, shielding becomes indispensable for the electronic devices to have a stable and good electromagnetic environment. For most electronic devices, the enclosure can not only support device, fixed, avoid physical damage and so on, but also play an important part of the electromagnetic compatibility.

The assembly, heat dissipation and human-computer interaction of enclosure inevitably produce apertures and these apertures may have effect on the shielding effectiveness of the enclosure. Therefore, many researchers at home and abroad have done a lot of research on apertures. [1] [2] [3] analyzed the effect on shielding effectiveness from the apertures in a rectangular metal body. [4] Adopted the combine of time domain and frequency domain method to analyze the characteristics of different frequency components in the time domain, and changes of the effect on shielding effectiveness caused by the length of apertures. [5] Adopted the transmission line method for high frequency to analyze the shielding effectiveness of enclosures. This method can predict the shielding effectiveness, but it also has certain defects for large frequency interval calculations, while. This paper aims at introducing a method to solve the problems above. Firstly we get a series of basic coupling feature set electromagnetic through the detailed analysis for the electromagnetic coupling element of enclosure. Then we create modeling, simulation and data processing modules for basic coupling element using the VBS scripting language of HFSS, and develop a visual simulation platform for to complete and analyze the modeling and simulation of the enclosure in use of the VC + + 6.0. Finally the feasibility and accuracy of this method is verified by comparing and analyze the effect on shielding effectiveness caused by the type, size and arranging form of apertures. Some rules for the design of the aperture in enclosure are concluded.

2. Simulation and analysis on shielding effectiveness of enclosure

2.1 The basic principle

Shielding than using a conductive material or a magnetic material to protect the area, aims at blocking or reducing the transmission of electromagnetic energy, by the conductive material or magnetic material absorbing and reflecting the electromagnetic interference. to weaken the effect of the disturbance energy. One role of electronic information equipment's enclosure is shielding. It is good to prevent external electromagnetic environment to affect the performance of electronic devices, and avoid internal electromagnetic interference sources leaking to external electromagnetic environment [6]. Literature [1] compared the FEM method of HFSS software and transmission line method calculating shielding near-field effectiveness of aperture arrays. Theoretical analysis and calculation results show that transmission line method is not suitable for the calculation of the near-field shielding effectiveness. Literature [2] researched the coupling problem of aperture in design of electromagnetic compatibility in use of the HFSS software. The results of the simulation and experimental verified the reliability of HFSS finite element method. Therefore, we use HFSS to complete the analysis of the shielding effectiveness of the enclosure, in order to achieve modeling, simulation and data display design automation. The data exchanging between VBS and visualize main program and framework are shown in Fig. 1:

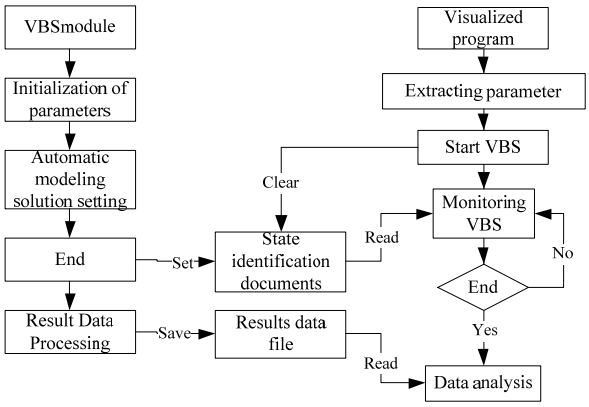


Fig. 1 VBS and the main program interaction

Firstly, this paper deeply analyzes the coupling elements of the enclosure by studying the electromagnetic interference coupling elements of typical electronic equipment's enclosure then, we develop a visual simulation modeling software platform using the C++ 6.0 software platform and data exchange program modules of VB script language, enabling the automation of design and analysis for enclosures of complex models. Meanwhile, we achieve automatic optimization of analysis and design for enclosure through an external program (eg: matlab) controlling the parametric enclosure modeling and simulation script files.

2.2 Coupling elements of the enclosure

For a closed metal casing, the shielding effectiveness should be relatively good. But the assembly, heat dissipation and human-computer interaction of enclosure inevitably produce apertures, so that the enclosure is not completely shielded, resulting electromagnetic leakage and the shielding effectiveness greatly reduced. For a typical electronic information equipment, the main components generating electromagnetic coupling include apertures on chassis, vents, lights, buttons, display screen, power line interface, CD-ROM, cable socket, knob and the various interface connected to external devices (eg: audio, screen, USB, serial communication interface). In order to make electronic devices with good electromagnetic environment, the reasonable design for enclosure is an important part of EMC design for electronic equipment.

2.3 Modular scripting language of coupling elements

HFSS is a High-performance software for the simulation of arbitrary 3D passive devices in full-wave electromagnetic field. It can calculate the electromagnetic field of arbitrarily shaped three-dimensional structure. HFSS based on finite element calculates the electromagnetic field distribution and electromagnetic shielding faster and more accurately under the conditions of complex media cabinet and properties, and it has an open scripting language that can complete the control the modular

modeling and simulation for coupling elements of the enclosure, providing the basis for automated modeling and simulation of enclosure [7, 8].

In this paper, HFSS scripting language is able to control the modeling and simulation of the enclosure. The scripting language program consists of modeling and analysis of the data of the simulation. Modeling and simulation module includes the establishment of the project, the enclosure coupling element modeling, boundary conditions set, excitation source settings, solving settings. The analysis of the data of the simulation module includes parameter variable set, data conversion, and data reading preservation content [9]. The modeling for the coupling element includes apertures on chassis, vents, lights, buttons, display screen, power line interface, CD-ROM, cable socket, knob and the various interface connected to external devices. The structure of scripting language for Modeling and Simulation is shown in Fig. 2.

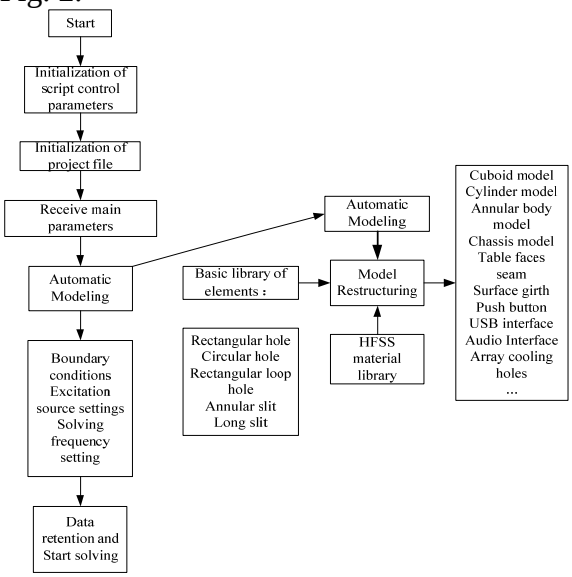


Fig. 2 Process of modeling and simulation scripts

The analysis of the data of the simulation shown as Fig. 3.

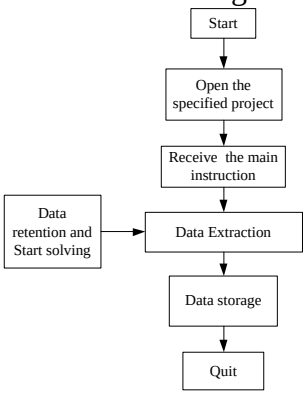


Fig. 3 Data processing script

2.4 Analysis software of visual simulation

We develop a visual modeling and simulation software in use of VC++6.0.

The basic process is:

1) Complete the parametric modeling for enclosure in the visual simulation platform

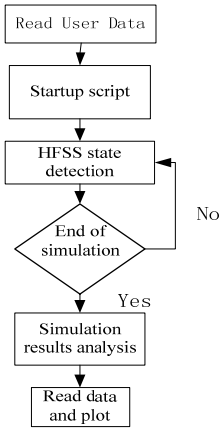
2) Read the parametric input by user, then the data will be processed and the instruction of modeling and simulation will be passed to the script command module

3) Start the script calculating parametric modeling and analysis of results for shielding effectiveness of Enclosure.

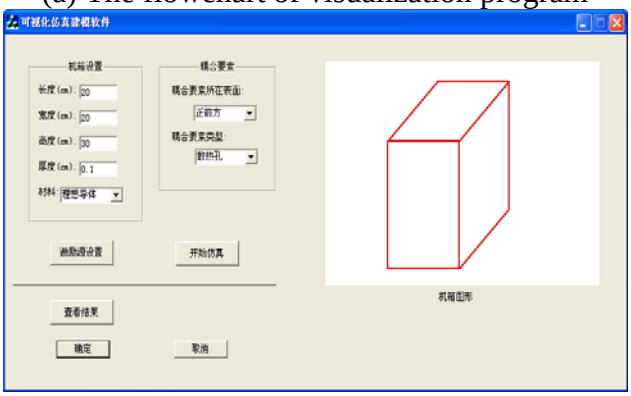
The overall visual of simulation software flow chart is shown in Figure 4 (a). The simulation for enclosure is achieved through VBS module controlling HFSS to calculate the shielding effectiveness of the enclosure.

Figure 4 (b) shows the main interface of the visual modeling and simulation software, where to read the main parameters of the overall structure of enclosure, which includes the size of the enclosure,

thickness of the enclosure, material properties of the enclosure and other parameters and coupling elements.



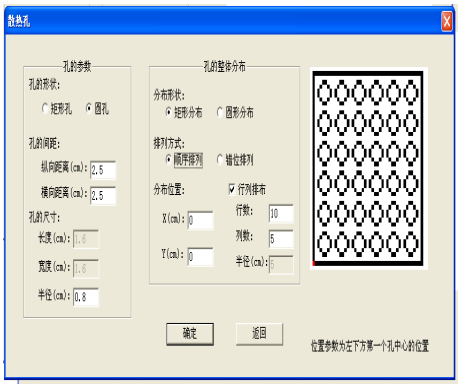
(a) The flowchart of visualization program



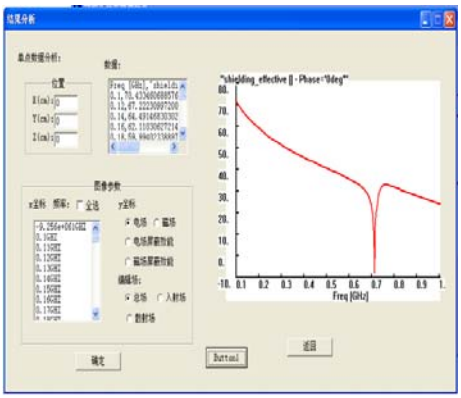
(b) The main interface of visualization program's

Fig. 4 Visual Simulation Software

In the visual simulation software, the coupling elements are a total of five kinds, and the setting interface of the vents is shown in Figure 5 (a), which mainly completes the model of vents array. The interface of post-processing visualization is shown in Figure 5 (b), which analyzes the electric field, magnetic field, electric field shielding effectiveness and magnetic shielding at a point inside the enclosure.



(a) The interface of vents settings



(b) The interface of Data Analysis

Fig. 5 The interface of visual simulation platform

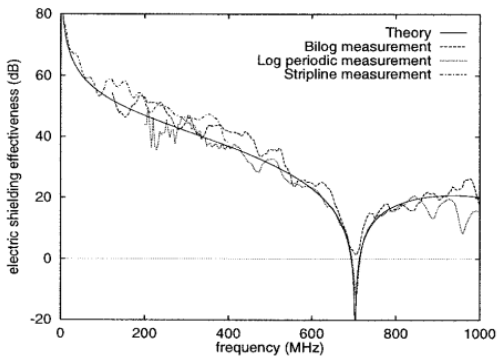
3. Examples of analysis

In order to verify the feasibility and accuracy of the software, this paper takes the test results from literature [2] as a reference. In this paper, we verify the feasibility and accuracy of the visual simulation software platform by establishing three models. We change the size of the apertures and the size of the enclosure for simulation, the parameters of model shown in Table 1. For model 1 and model 2 just change the size of the aperture, while the model 1 and model 3 just change the size of the enclosure.

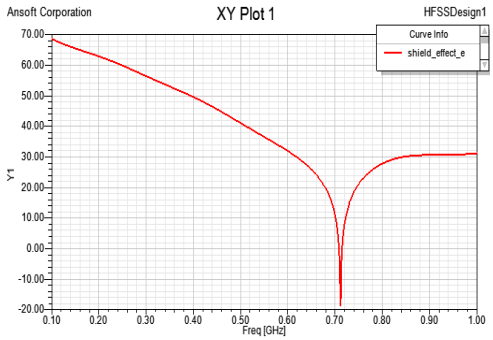
Table 1. Model parameters

	Model 1	Model 2	Model 3
Size of enclosure	300x120x300 [mm^3]	300x120x300 [mm^3]	222x55x146 [mm^3]
Thickness	1[mm]	1[mm]	1[mm]
Material	Aluminum	Aluminum	Aluminum
Size of aperture	100x5[mm^2]	200x30[mm^2]	100x5[mm^2]
Frequency	0-1 [GHz]	0-1 [GHz]	0-1 [GHz]
Polarization	Vertical	Vertical	Vertical
Detection point	Center of enclosure	Center of enclosure	Center of enclosure

Figure 6 is the curve of shielding effectiveness of model 1. Figure 6 (b) is the curve of electric field shielding effectiveness of a point at the center of enclosure, calculated by the visual simulation software. Figure 6 (a) is the curve of the electric field shielding effectiveness of enclosure with the same parameters of enclosure. The data simulation and the test data are a good fit by comparing, and they both have a resonance in the 700MHz or so, and the values of shielding effectiveness remain the same.



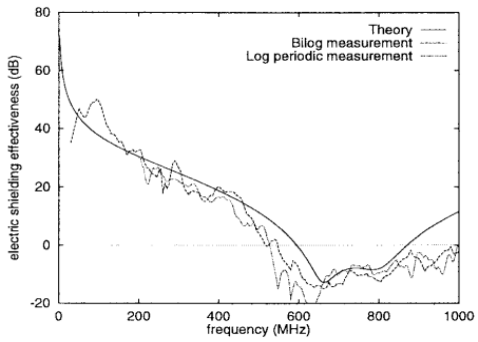
(a) Test curve of electric field shielding effectiveness



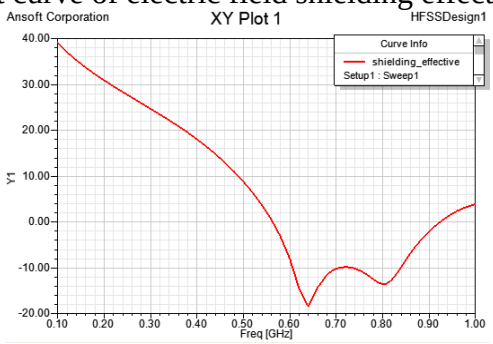
(b) Simulation curve of electric field shielding effectiveness

Fig. 6 Shielding Effectiveness contrast curve of model 1

Model 2 is based on an enclosure that the volume is 300x120x300 mm^3, an the aperture size 200x300mm^2. Figure 7 (b) is the curve of electric field shielding effectiveness of a point at the center of enclosure, which is changing with the frequency changing. We find that simulation data and test data are a good fit. Through comparing the model 1 and the model 2, we find that the shielding effectiveness at the center of enclosure will worse if the size of the aperture becomes larger. It further illustrates the validity of the model with the actual situation.



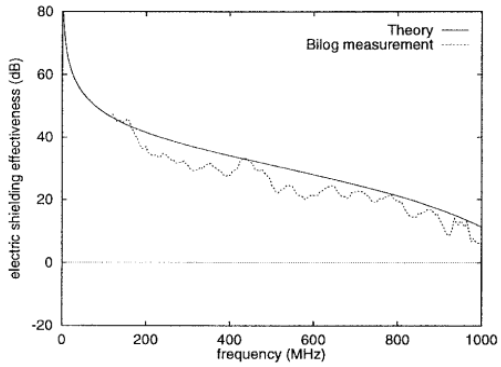
(a) Test curve of electric field shielding effectiveness



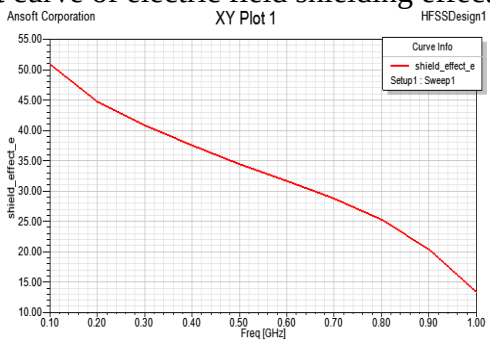
(b) Simulation curve of electric field shielding effectiveness

Fig. 7 Shielding Effectiveness contrast curve of model 1

Model 3 is based on an enclosure that the volume is 222x55x146mm^3, with a 100x5mm^2 rectangular aperture In front of the enclosure. In figure 8, we can see that the resonant frequency will change with the size of enclosure changing. The curve of electric field shielding effectiveness and measured data are good matched.



(a) Test curve of electric field shielding effectiveness



(b) Simulation curve of electric field shielding effectiveness

Fig. 8 Shielding Effectiveness contrast curve of model 1

4. Conclusion

In this paper, we analyze and summarize the electromagnetic interference coupling elements of a typical enclosure, and establish parametric and universal model for electromagnetic field simulation .Then establish a visual simulation platform for the simulation and analysis of electromagnetic coupling element of enclosure based on VC++ 6.0. Lastly, we verify the feasibility and accuracy of the visual simulation software platform by establishing three models. Through analyzing the type, shape and arrangement of the aperture, we can improve shielding effectiveness of the enclosure to some extent by trying to use square apertures In this paper, we can achieve the optimal design for the shielding effectiveness of enclosure controlled by the external program.

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