Electromagnetic Interference through Vent Array on Computer Enclosure

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Abstract—**In this paper, the finite-difference time-domain (FDTD) method is used to study electromagnetic interference through vent array on computer enclosure. Ultra-wide Bandwidth (UWB) is used as the source, and both time-domain electromagnetic waves and field distribution in the enclosure are monitored. It can be seen that the coupled electric field in both three directions are large. From the field distribution, it is clear that the coupled electric field near the vent array is tremendous. Thus it can be concluded that the coupled electromagnetic interference (EMI) into the enclosure through vent array is quite large.**

Keywords—component; formatting; style; styling; insert (key words)

I. Introduction (*Heading 1*)

With the development of the electronic technology, electronic equipments require to work in a quiet electromagnetic environment. Electromagnetic shielding is frequently used to reduce the electromagnetic interference of electronic equipment [1]. Shielding computer enclosure is an effective way to diminish the electromagnetic interference (EMI). However, in most applications, slots, holes, and even a window aperture have to be created on the walls of the computer enclosure for signal wiring, power supply, and dispersion. These slots, unfortunately, provide electromagnetic energy coupling paths that allow outside electromagnetic waves to propagate into the enclosure; they thus degrade the shielding effectiveness (SE). Therefore, it is necessary to analyze the SE of the shielding enclosures. EMI introduced into the enclosure by lines are as serious as that by coupling, however, only the EMI introduced by coupling are considered here.

The finite-difference time-domain (FDTD) method, which provides a simple and efficient way of solving Maxwell' equations for a variety of problems, has been widely applied in solving many types of electromagnetic coupling problems [2-5]. It is good at predicting the SE of a particular enclosure for it has numerous time-domain and frequency-domain information.

To simulate the EMI coupled into the computer enclosure, Ultra-wide Bandwidth (UWB) is used as the source. Total-field/scattered-field (TF/SF) boundary [2] is used to introduce the UWB. Convolution Perfectly Matched Layer (CPML) [6] absorbing boundary, which is good at solving late-time reflects brought by traditional PML while simulating fields with very long time-signatures, is used to truncate the computational domain. Considering that the electromagnetic interface is mainly penetrated in through apertures into the enclosure rather than that through the walls, the perfect electric conducting plane is used to model the shield enclosure.

To analysis electromagnetic interference through slots of vent array on computer enclosure, a typical industrial controlling computer is used and the problem is simulated by the FDTD method.

II. The Computational Model

To be simply, an industrial control computer enclosure is involved here. The width of the enclosure is 450 mm, and 420 mm in length and 120 mm in height. In Fig.1 is graphed the vent array on the front face, which is composed of four line slots array with 20 small slots in each line. The dimension of the vent array is 12 cm×10 cm. The dimension of small slots is the same, and is 15 mm in height and 3mm in width. The distance between each slot is 3 m in a line, and 10 m between adjacent array lines.

A. The Vent Array on the enclosure

The vent array on the back face is graphed in Fig.2,

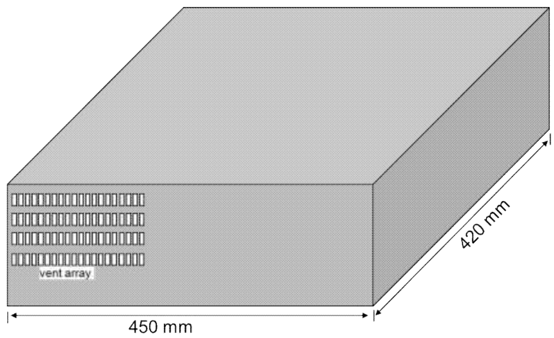

Figure 1. Waveform of the high power pulse.

which is composed of one line small slots. There are 40 small slots in all, and the dimension of each slot and the distance between adjacent slots is the same as that on the front face.

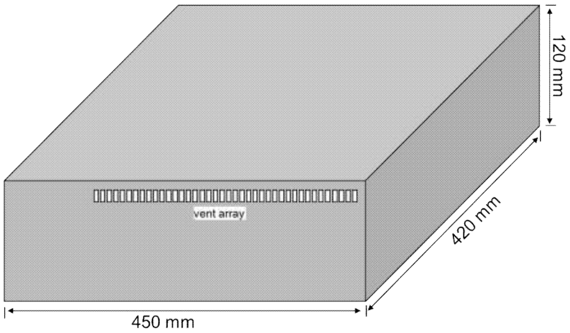

Figure 2. Waveform of the high power pulse.

B. UWB

UWB is used as the source here, whose waveform can be simulated as

$$E(t) = E_0 k(t - t_0)\exp(-\frac{4\pi(t - t_0)^2}{\tau^2}), \qquad (1)$$

where $k = \sqrt{8\pi e} / \tau$, and E_0 is peak value of the electric field, τ is the pulse width, t_0 is the delay time, the rising edge is $\tau/4$, waveform is shown in Fig. 3.

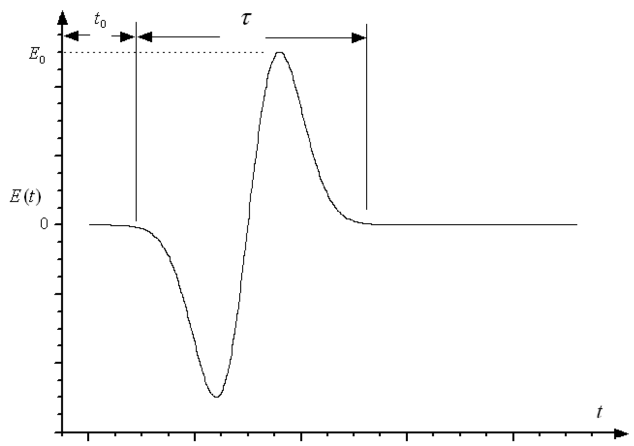

Figure 3. Waveform of the high power pulse.

C. SE

To evaluate the SE of the enclosure, all the three directional electromagnetic fields at the center of the enclosure is monitored first, and the waveform of the largest field direction is graphed. Additionally, the peak field value of the waveform is recorded and used to derive the total electric field component

$$E_p(t) = 20\log\left[\sqrt{E_x(t)^2 + E_y(t)^2 + E_z(t)^2}\right] \text{dBV/m} \qquad (3)$$

III. NUMERICAL RESULTS

To analysis the coupled EMI into the computer enclosure through the vent array on the two faces, FDTD is occupied. Cubic FDTD cells with the grid dimension $\Delta = \Delta_x = \Delta_y = \Delta_z = 1.0$ mm is used and the time step is $\Delta t = \Delta/2c$, where c is the speed of light in the free space. The computational domain is terminated by a 15-layer CPML [29].

To study the EMI coupled into the enclosure, the enclosure is illuminated by the HPM. The coupled electric field component into the enclosure in the three directions is monitored respectively, and the largest one is graphed. Additionally, distribution of the largest total electric field component is also listed.

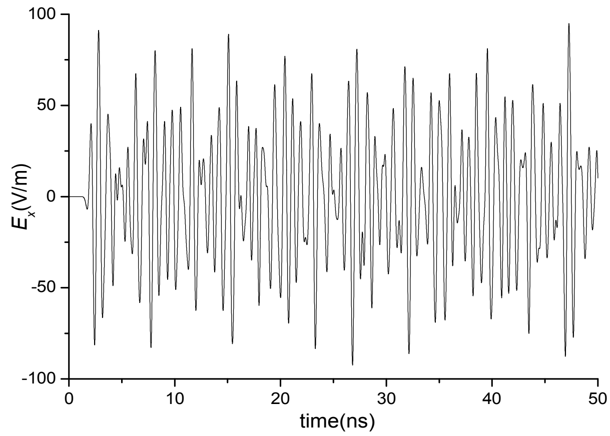

Figure 4. Waveform of the high power pulse.

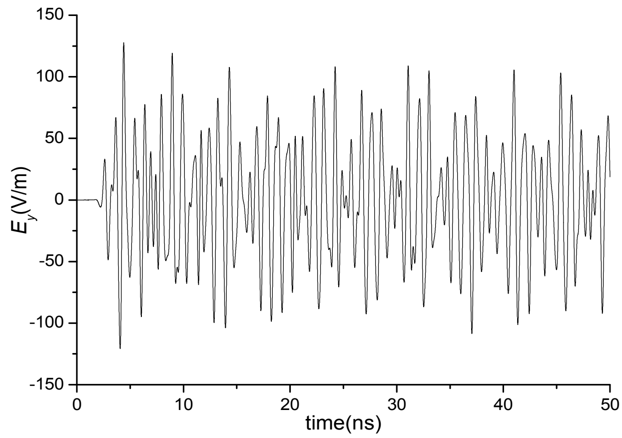

Figure 5. Waveform of the high power pulse.

With FDTD simulation, the time-domain electromagnetic field is monitored at the center of the enclosure. In Fig. 4 is graphed the electromagnetic field in x direction. It can be seen that resonance happens, and the amplitude of the coupled electric field reach 95.2 V/m.

In Fig. 5 is graphed the electromagnetic field in *y* direction. The amplitude of the coupled electric field reaches 127.7 V/m. In Fig. 6 is graphed the electromagnetic field in *z* direction. The amplitude of the coupled electric field reaches 112.8 V/m.

It can be seen from Fig.4-6 that the electric field coupled into the enclosure is large; resonance occurs in the enclosure and the amplitude decreases very slowly.

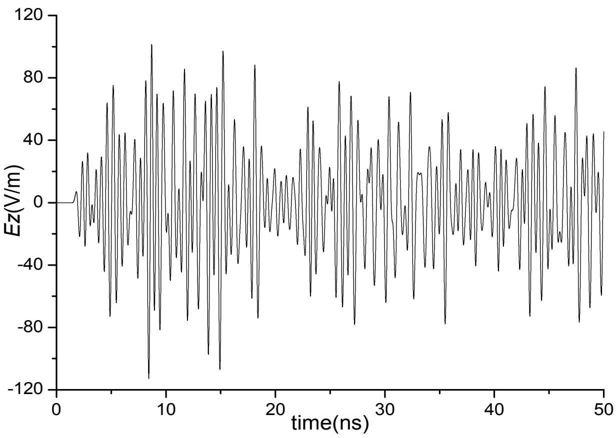

Figure 6. Waveform of the high power pulse.

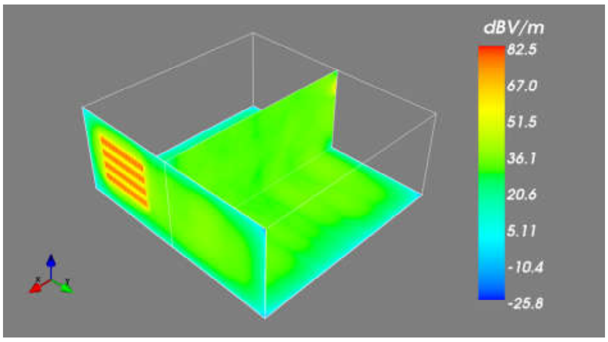

Figure 7. Waveform of the high power pulse.

In Fig. 7 is graphed the total electric field distribution in the enclosure, and it is clear that the four lines of slots are conspicuous on the enclosure. It can be seen from Fig. 7 that a resonance occurs in the enclosure. The amplitude of the electric field reach 80 dBV/m near the vent array, and the amplitude is larger than 35 dBV/m at most areas. Thus, it can be concluded that the *SE* of the enclosure is limited when the vent array exist on the two faces of the enclosure.

IV. CONCLUSIONS

In this paper, the EMI coupled through vent array into computer enclosure is studied. UWB is used as the EMI source, and both the time-domain waveform in three directions and the field distribution in the enclosure are monitored. From the monitored electric field, it can be seen that the coupled electric field both in three directions are large. From the field distribution, it is clear that the coupled electric field near the vent array is tremendous. Thus, it can be concluded that the coupled EMI into the enclosure through vent array is large, and some efficient methods are needed to be improve the compatibility when the computer are worked under UWB environments.

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