Numerical Analysis of Electromagnetic Field Distribution in Hollow Metallic Rectangular Parallelepiped with Roof

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***Abstract*— The hollow metallic rectangular parallelepiped with roof is excited by a dipole antenna located near it. The induced current distribution on the surface of parallelepiped and the neighboring electric field are numerically investigated by using the electromagnetic simulator WIPL-D based on the method of moment. The calculation frequency is 945 MHz.**

***Index Terms* — metallic box, WIPL-D, method of moment, current distribution, electric field.**

I. INTRODUCTION

With the development of numerical analysis method, many kinds of electromagnetic simulators are used for the analysis of antennas [1]. Authors have calculated the center-fed hollow cylindrical dipole antenna and the center-fed solid dipole antenna by using the electromagnetic simulators WIPL-D and AWAS based on the method of moment [2]. Then, authors have calculated some microstrip antennas by using the electromagnetic simulators WIPL-D and IE3D based on the Method of Moment, Micro-Stripes based on the TLM (Transmission Line Matrix) method and Fidelity based on the FDTD (Finite Difference Time Domain) method [3]-[7]. These simulators are applicable to the antenna consisting of conducting and dielectric materials with finite size. The input impedance and the radiation characteristics of the antenna have been calculated and compared with the measured data.

Due to the development of GUI (graphical user interface) of the simulators, the electromagnetic field distribution in the vicinity of antenna is easily observed. By using GUI, the user can easily understand the physical phenomenon and design the antenna.

Recently, the reception antennas of the AM and FM radio broadcasting and the GPS (Global positioning system), the antenna of the keyless entry system and the antenna of ETC (electronic toll collection) and VICS (Vehicle Information and Communication System) are installed in a lot of cars. In the keyless entry system, for example, the electromagnetic wave transmitted from the key outside of car is weak and the strength of electromagnetic field varies within a car [8]. Therefore, it is important to investigate the relation between the electromagnetic field distribution and the structure of the car. Authors have numerically investigated the electric field distribution within the hollow metallic rectangular parallelepiped with an aperture on its top when the horizontal polarized wave is radiated from the dipole antenna located near the parallelepiped [9]. In the reference [9], it is shows that the current distribution on the infinitely thin conductor is same as the summation of currents on inner and outer conductor of thickness 1 mm. Then the relation between the current distribution on the parallelepiped and the electric field distribution within it is discussed.

In this paper, the hollow metallic rectangular parallelepiped with roof is excited by a dipole antenna located near it. The roof is located above the aperture of the analytical model in reference [9] and supported by four pillars from the edge of aperture. The induced current distribution on the surface of conductor and the electric field distribution within the parallelepiped are numerically analyzed. In the numerical analysis, the electromagnetic simulator WIPL-D based on the method of moment is used [10]. The calculation frequency is 945 MHz.

II. ANALYTICAL MODEL

Figure 1 shows the analytical model of the hollow metallic rectangular parallelepiped with roof. The electromagnetic field is radiated from the dipole antenna. The radius r of the dipole antenna is 1 mm, and its length s is 160 mm. The distance D between the parallelepiped and the dipole is 1,020 mm. The dipole antenna and the rectangular parallelepiped are located above the infinite ground plane. The height h2 of dipole antenna is 300 mm. The rectangular parallelepiped is located 100 mm (h1) above the ground plane. The parameters of parallelepiped are as follows. L = 1,300 mm, a = 400 mm, b = 350 mm, c = 350 mm, e = 550 mm, w1 = 350 mm, w2 = 400 mm, and w3 = 100 mm. The height of pillar h3 is 230 mm. The thickness of conductor is t = 1 mm. The calculation frequency is 945 MHz. In the numerical analysis, the electromagnetic simulator WIPL-D based on the method of moment is used. In the numerical analysis by WIPL-D, the dipole antenna is excited by the delta function generator.

III. RESULTS AND DISCUSSION

The relation between the current distribution and the electric field distribution will be discussed. Figure 2 and 3 show the current amplitude distributions on the outer and inner surfaces of parallelepiped, respectively. On the inner surfaces of conductors, the standing wave distribution of current is induced in the direction of dipole antenna. Since the directly incident wave does not exist, the induced current on the inner surface may be due to the diffraction through the aperture.

Figure 4 and 5 show the electric field distributions in the vertical plane x = 100 mm and 210 mm, respectively. Figure 6, 7 and 8 show the electric field distribution in the horizontal plane z = 150 mm, 300 mm, and 400 mm, respectively. Within the parallelepiped, the vertical (z) component of electric field is strongly excited, although the horizontally polarized electromagnetic wave is incident.

IV. CONCLUSION

The hollow metallic rectangular parallelepiped with roof has been excited by the horizontally polarized dipole antenna located near it. The induced current distribution on the parallelepiped and the electric field distribution within it have been numerically analyzed by the electromagnetic simulator WIPL-D based on the method of moment. The calculation frequency is 945 MHz.

On the inner surface of parallelepiped, the horizontal component of current is induced. Within the parallelepiped, the vertical component of electric field is strongly excited due to the horizontal component of induced current. The mode of the vertical component of electric field depends on the geometry of conducting box.

In the next step, the electromagnetic field distribution within the hollow rectangular parallelepiped will be analyzed in the case of vertically polarized wave incidence. The comparison of the calculated electric field distribution and the measured result is also needed.

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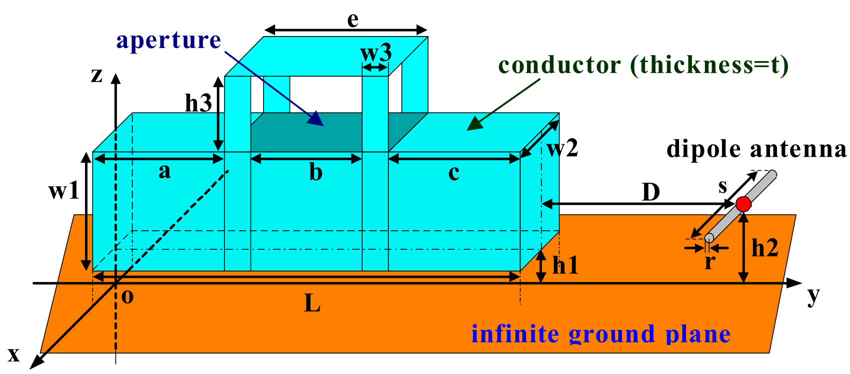
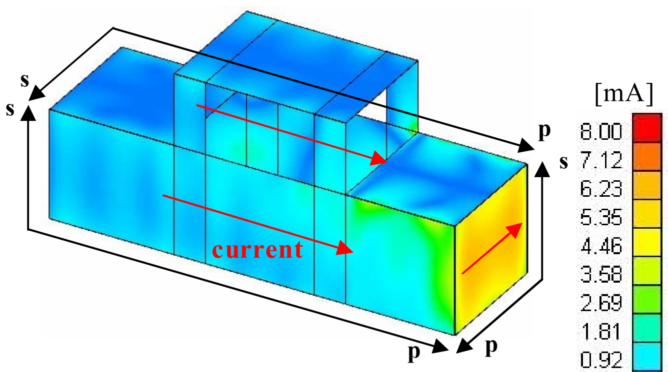
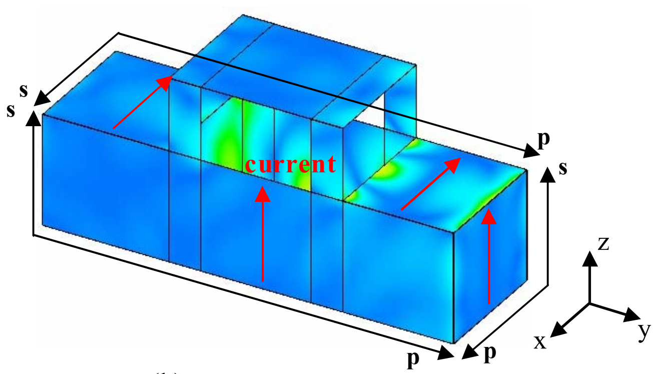


a=400mm, b=350mm, c=350mm, e=550mm, D=1,020mm, h1=100mm, h2=300mm, h3=230mm, L=1,300mm, w1=350mm, w2=400mm, w3=100mm, s=160mm, r=1mm.

Figure 1. Hollow metallic rectangular parallelepiped with roof.

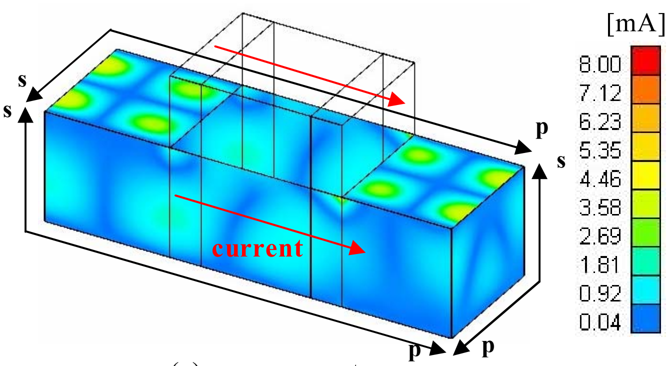


(a) p component

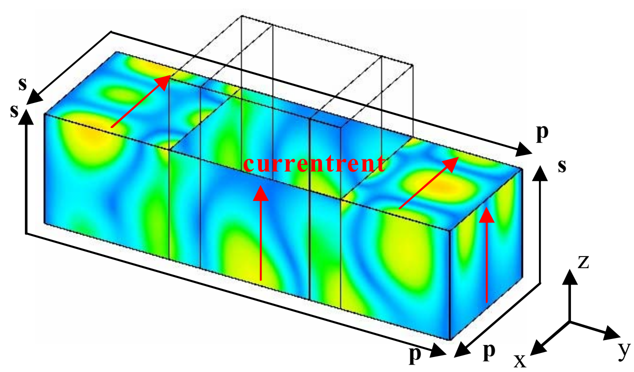


(b) s component

Figure 2. Current amplitude distribution on outer surfaces of parallelepiped.

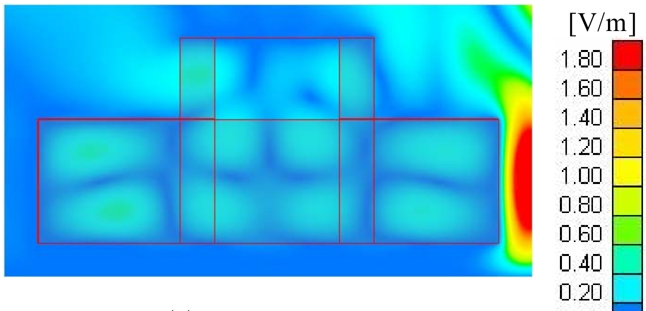


(a) p component

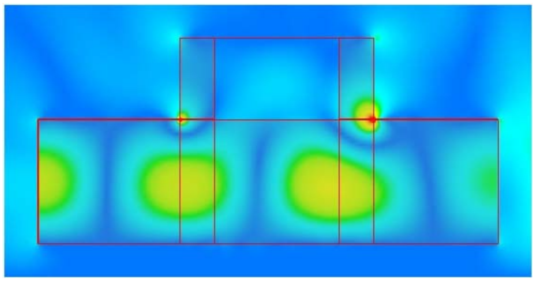


(b) s component

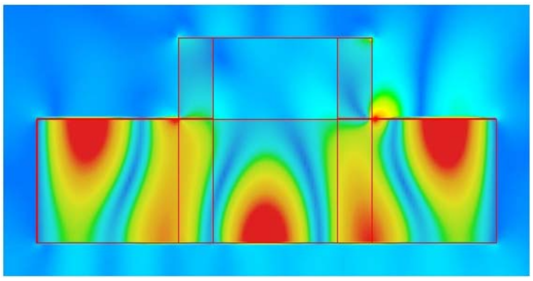
Figure 3. Current amplitude distribution on inner surfaces of parallelepiped.



(a) x component

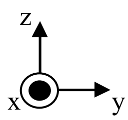


(b) y component



(c) z component

Figure 4. Electric field distribution in vertical plane x = 100 mm.



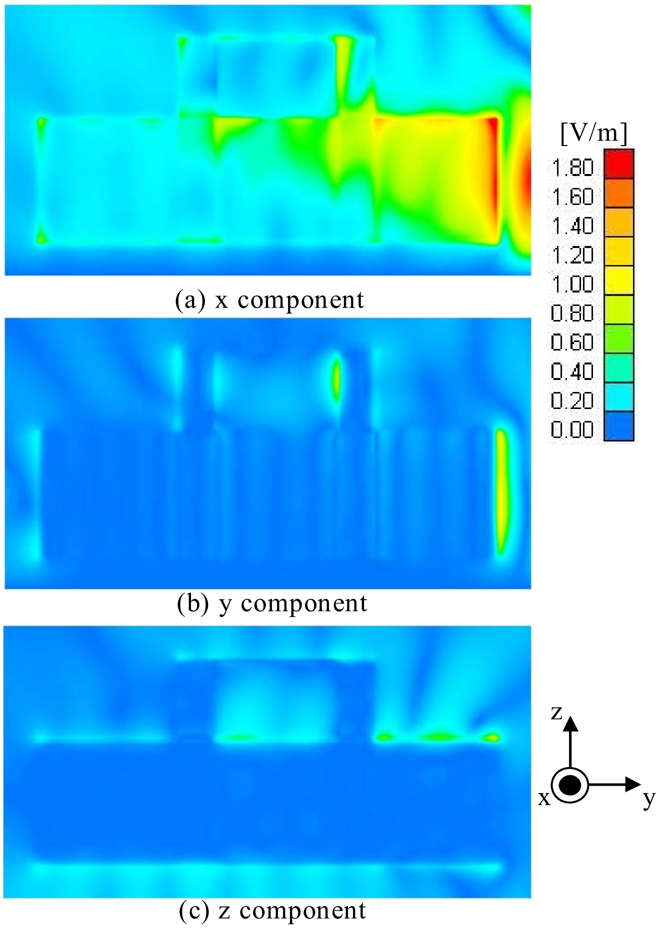


Figure 5. Electric field distribution in vertical plane x = 210 mm.

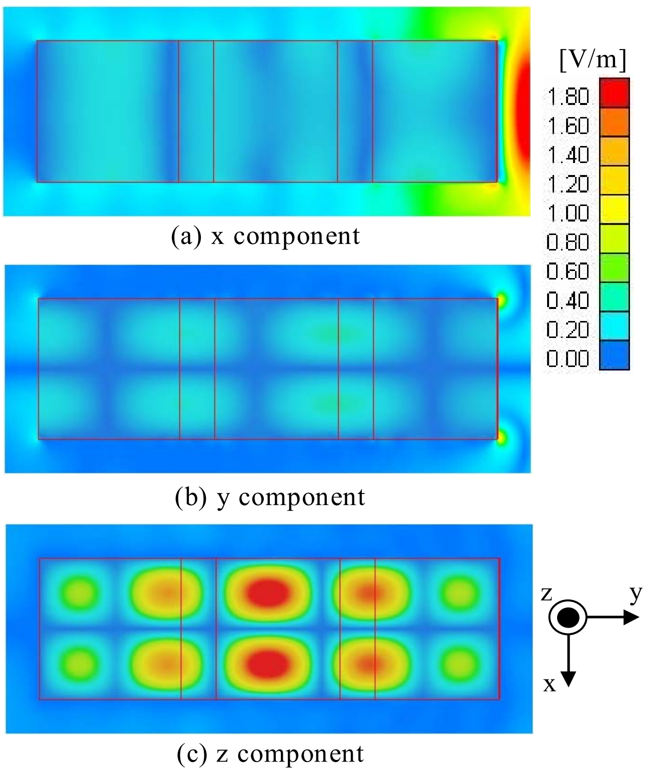


Figure 6. Electric field distribution in horizontal plane z = 150 mm.

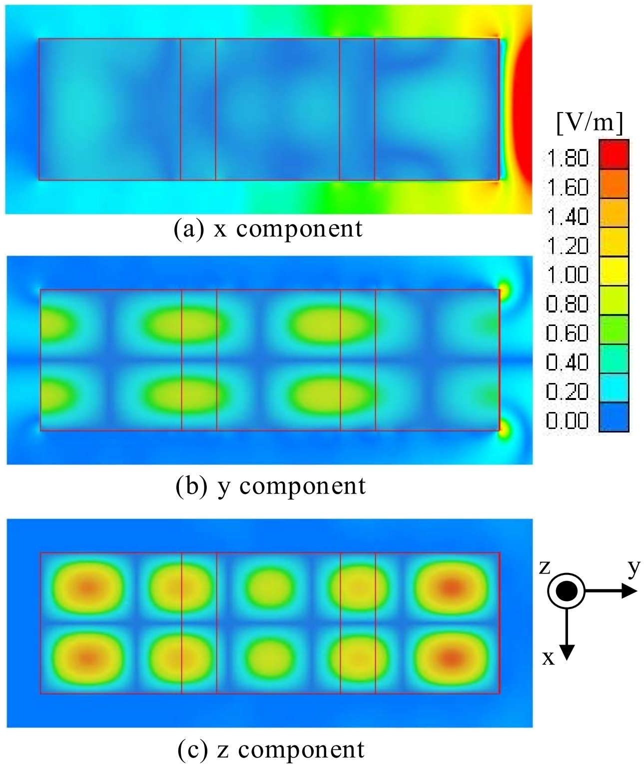


Figure 7. Electric field distribution in horizontal plane z = 300 mm.

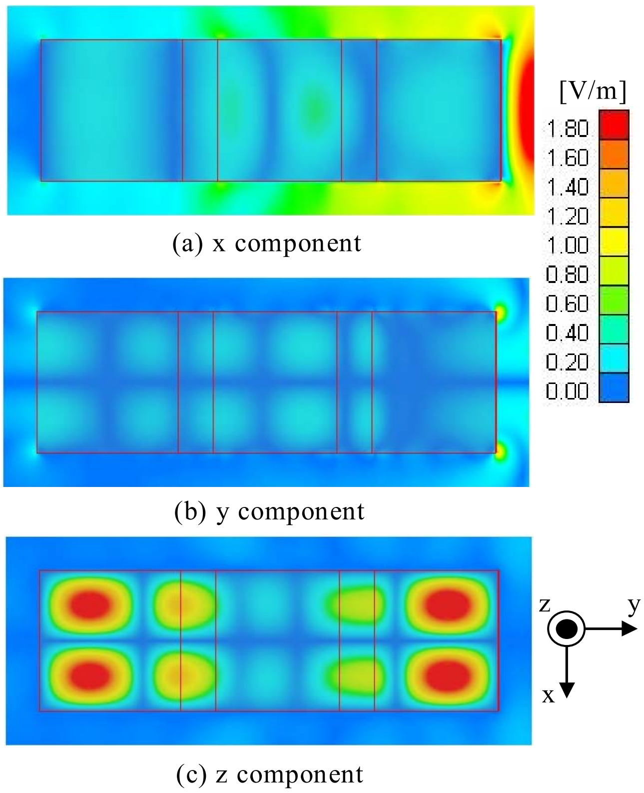


Figure 8. Electric field distribution in horizontal plane z = 400 mm.