ANALYSIS OF BEAM TILTING BEHAVIOUR FOR THE MEASUREMENT OF EUT RADIATING SLOTS

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Abstract - **In this paper, beam tilting behavior of radiating slots is introduced. When the radiating field intensity is measured in EMI/EMC test, the receiving antenna or probe must be moved along its vertical axis because of its beam tilting behavior. The radiation pattern is measured by near-field measurement system and verified by the Finite-Difference Time-Domain (FDTD) Method. The far-field pattern was obtained from near-far field transformation by using near-field data. The beam tilted about 18° at 10.82 GHz and the FDTD method provides a good result to this measurement.**

Index Terms – **EMI/EMC, FDTD, Beam Tilting**

I. Introduction

To measure the EMI/EMC characteristics of equipment, the open-site RF measurement facility was used [1]. This test site should be located in the countryside to prevent the electromagnetic noise and the ground is covered with a large metal plate or meshes which has known conductivity and dielectric constant to predict the reflection properties. In this measurement, the important factor is to detect the maximum direction of emission from EUT. For this reason, the EUT must be rotated or the receiving antenna can be adjustable in height to detect the maximum radiated field as a function of azimuth or elevation angle.

In this paper, the main beam tilting behavior of the radiating slots will be analyzed and suggested the basis of the reason why we must move the EUT or receiving antenna along azimuth or elevation direction. Fig. 1 describes this situation. Because of the array effect of the slots, the main beam direction is tilted in azimuth or elevation direction [2]. Therefore, the EUT should be rotated in azimuth direction or the receiving antenna should be scanned along vertical axis.

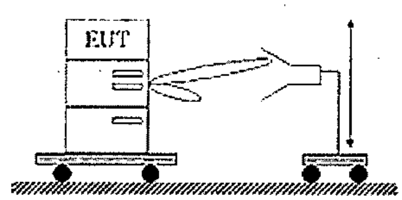

Fig. 1. Receiving antenna move along the vertical axis to detect the maximum emission from EUT.

To support this test procedure, the cavity-backed slot antenna was manufactured as EUT model according to the CISPR 22 standard shown in Fig. 2 and analyzed by the FDTD method [4]. It is manufactured to cover the 1 GHz ~ 18 GHz frequency range.

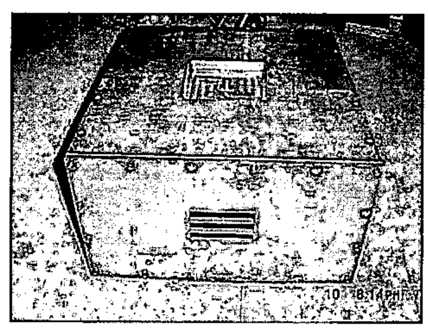

Fig. 2. Cavity-backed slot antenna.

This paper is organized as follows. Section II describes the basic ideas of the FDTD method and the FDTD model of EUT to be analyzed. Section III describes the near-field measurement system and its result will be provided with numerical analysis. Finally a brief description of this paper will be presented in last section.

II. The FDTD Analysis of the Slots

The first step in the FDTD analysis is to build the 2-D or 3-D geometrical model by 2-D or 3-D CAD programs and then divide the CAD model into rectangular or cubical meshes. The mesh size must smaller than the Courant stability condition as follows.

$$\Delta t = \frac{1}{c\sqrt{1/\Delta x^2 + 1/\Delta y^2 + 1/\Delta z^2}} \qquad (1)$$

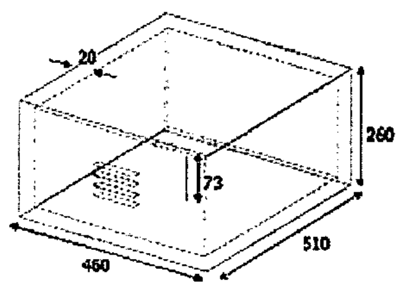

Fig. 3. The 3-D geometrical model of cavity and it's size. The dimension was chosen similar to the electrical equipment such as a microwave oven or computer system.

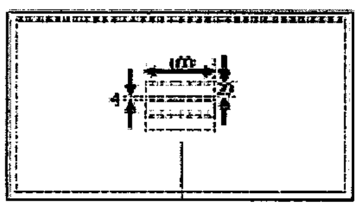

Fig. 4. The configuration of slots.

The geometrical model of cavity is showed in Fig. 3 and 4 respectively. The thickness of each side of panel is 20 mm and the length of monopole is 73 mm. The monopole located at the center of the cavity. The slots are positioned at the center of the front panel. In Fig. 4 shows the configuration of the front panel. The dimension of slot is 100 mm × 20 mm and the gap of each slot is 4 mm. Because the frequency sweep range is 9~11 GHz and the gap between the slots is 4 mm, the mesh size should be less than 4 mm according to the Courant stability condition,.

The geometrical model of cavity after mesh generation is showed in Fig. 5. The each side of the cavity sets as a conductor which has a finite conductivity, $\sigma = 5.76\times10^7$ (S/m). The source model used in this analysis is the voltage-gap model. To calculate the return loss of the cavity-backed slot antenna in frequency domain, a form of Gaussian pulse is commonly used in FDTD technique. In this case, however, the frequency to analyze is about 10 GHz, a differentiated Gaussian pulse of the form is used as follows [3].

$$V(t) = -V_0(t/\tau_p)\exp(-[(t/\tau_p)^2 - 1]/2) \qquad (2)$$

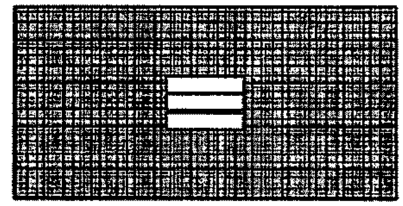

Fig. 5. The geometry of cavity after mesh generation. The mesh size is 2 mm in each direction.

The time interval determined according to the equation (1)

$$\Delta t \le \Delta/1.73c = 3.85\ p\sec \qquad (3)$$

where $\Delta \equiv \Delta x = \Delta y = \Delta z$ and c is a speed of light. The time step size, that is the number of iteration, was chosen as 2^{15} times. The simulation result such as return loss, radiation pattern and measurement of those will be introduced in the following section.

III. Numerical and Experimental Results

Fig. 6 shows the return loss of cavity-backed slot antenna. The solid line represents the FDTD simulation and the dashed line represents the measurement result. It shows that the measured resonant frequency is 10.6 GHz and 10.82 GHz. The simulated result represents that the resonant frequencies are 10.67 GHz and 10.8 GHz, respectively. This shows that there are good agreements between the measured and simulated results which deviation is located within the 0.2 percentages.

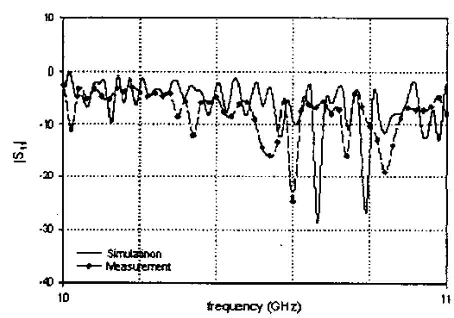

Fig. 6. The return loss of the cavity-backed slot antenna.

The radiation pattern is calculated by the FDTD method. The simulation result is compared with the experiment result by near-field measurement system. Fig. 7 shows the near-field measurement system. The waveguide probe scans the near-field region in front of the EUT and then the near-field data saved is transformed into the far-field radiation pattern.

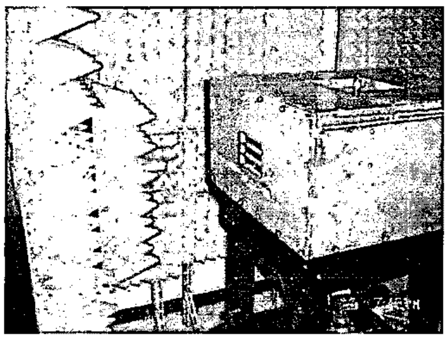

Fig. 7. The near-field measurement system.

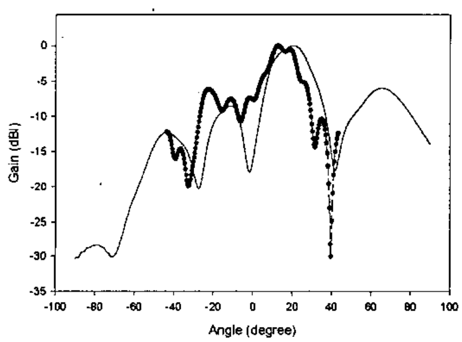

Fig. 8. The radiation pattern of cavity-backed slot antenna. The dotted line is a measured data and solid line is a simulation data.

Fig. 8 represents the results of the measurement and simulation. The radiation pattern is represented in elevation plane and can be found that the main beam tilted up from the horizontal plane about 18°. The measurement data range is from -45° to 45°.

IV. Conclusion

In EMI/EMC test, to detect the maximum radiating field from EUT correctly, the EUT or receiving antenna should be moved along azimuth or elevation direction. To support this test procedure, the FDTD analysis and measurement was performed in this paper.

ACKNOWLEDGMENT

This work is supported by the National Research Laboratory (NRL) of Ministry of Science & Technology, Korea under contract M1-0203-00-0015.

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