ANALYSIS OF SUPPRESSION EFFECT OF EMISSION FROM PRINTED CIRCUIT BOARD BY CONDUCTING PLATE

Teruo Tobana, Takayuki Sasamori, Kohshi Abe
Dept. of Electronics and Information Systems, Akita Prefectural University
Honjyo, Akita, 015–0055 Japan
tobana@akita-pu.ac.jp

1 Introduction

Recently, Emission from electric equipment is one of the most crucial topics. Specially, the progress of information technology causes high-speed communication and complicates an electromagnetic environment. Whereas, since the susceptibility of equipment has increased by low voltage operations of its circuits, the malfunction of various electric equipment may be easily caused by the undesired electromagnetic waves from other equipment. Here,it is considered that undesired electromagnetic waves from equipment should be mainly generated at microstrip lines and ground planes of printed circuit boards(PCB) and radiated from aperture of a case and power lines.

In the case of emission from a PCB, the radiated field increases as the width of ground plane decreases, because a small ground plane causes a large common mode current [1]. The emission by the common mode current flowing around the whole PCB should be generated as same as that of the dipole antenna. When a conducting plate of the infinite size is placed parallel nearby a dipole antenna, the electromagnetic field by the conducting current flowing in the antenna and that by its image current are canceled. Hence, placing a large conducting plate nearby a PCB, emission by the common mode current on the PCB should decrease.

In this paper, the authors propose a new suppression method of emission from a PCB using a conducting plate placed nearby the PCB's ground. Some researches have studied to suppress emission from a PCB using a conducting plate[2], but in our method, which is different from the others, a conducting plate is just placed below the PCB (the ground side). In order to evaluate the suppression effect of our method, a numerical analysis of the power radiated from a microstrip line on the PCB with a conducting plate is carried out. The finite different time domain (FDTD) method is applied to the analysis [3]. Furthermore, we measure the max radiation power from the PCB to verify the analysis results.

2 Numerical Analysis

2.1 Analysis Model

The geometry of the PCB and the thin conducting plate for suppressing the radiation power is shown in Fig. 1. The PCB consists of the microstrip line on the dielectric substrate of ϵ_r=2.55 and thickness T=1.6mm. The microstrip line has the length l=40mm and the width w=4.2mm. A signal circuit of output impedance 50Ω is connected to one end of the microstrip line and a open circuit is connected to the other end. In this analysis model, the rectangular coordinate system is used. The feeding point at the end of the signal side is made to be the origin of the coordinate. The conducting plate is rectangular with a size of $L_c \times W_c$, and its position, (x_c, y_c, z_c), is denoted to the center point of it.

The power P_r radiated from the PCB is calculated with integrating the Poynting vector over a surface enclosing both of the microstrip line and the conducting plate. Similarly, the reference radiation power P_0 radiated from the PCB without the conducting plate is also calculated. Moreover, in order to evaluate the suppression effect of the conducting plate we introduce the suppression effect S given by

$$S = P_0/P_r. \tag{1}$$

As the numerical analysis method, we use FDTD method with the PML absorbing boundary condition[4] as outer radiation boundary condition.

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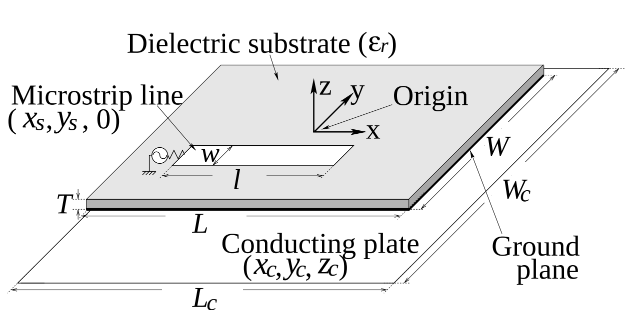

Figure 1: The geometry of the PCB and the conducting plate

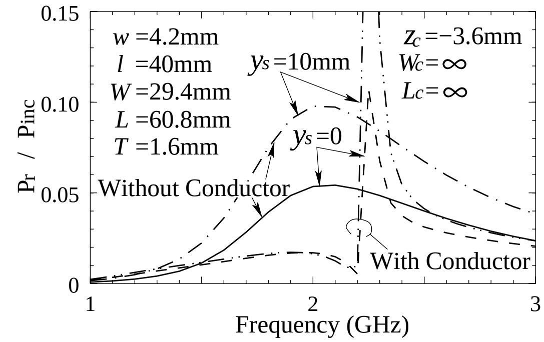

Figure 2: The radiation power from PCB with infinite conducting plate

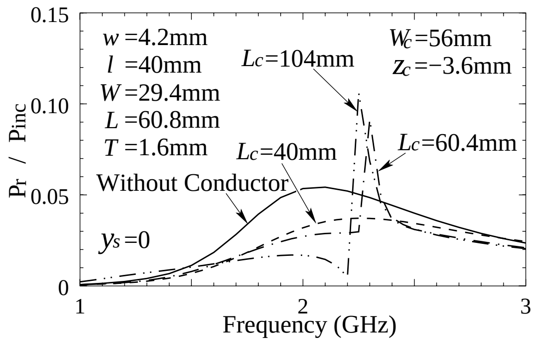

Figure 3: The radiation power from PCB with conducting plate for various L_c

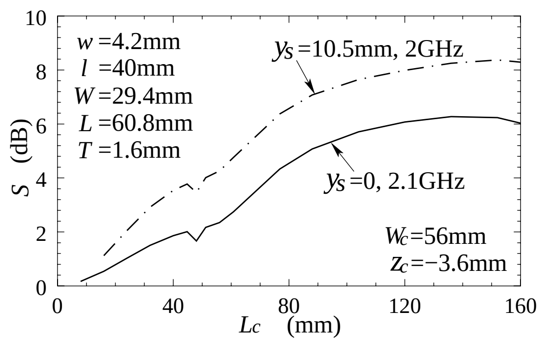

Figure 4: Suppression effect of the conducting plate as a function of L_c

2.2 Numerical Results Using Rectangular Conducting Plate

In order to verify the cancellation of emission by the image current below the conducting plate, the radiation power normalized by incident power P_{inc} from the PCB nearby the infinite conducting plate for y_s=10mm and y_s=0 are calculated and shown in Fig.2. It shows that the radiation power from the PCB for y_s=10mm without conducting plate is larger than that for y_s=0 because as a microstrip line approaches the edge of PCB the common mode current increases. Whereas the radiation power from each PCB for y_s=10mm or y_s=0 with the conducting plate is similar level and smaller than that without conducting plate, except for the frequency of about 2.3GHz where the peak radiation occurred. The peak radiation should be generated by the resonance in the space between the PCB and the conducting plate.

The normalized radiation power with a finite conducting plate for W_c=56mm and various L_c are calculated and shown in Fig.3. It shows that as L_c decreases the peak radiation level decreases and it is removed for L_c=40mm. Further, the suppression effect S of the conducting plate for W_c=56mm at the frequency where a local maximum of the radiation occurs are shown in Fig.4 as a function of L_c. It shows that each suppression effect S increases as L_c increases and they are converge for L_c >100mm, roughly.

The normalized radiation power with a finite conducting plate for L_c=40mm and various W_c are calculated and shown in Fig.5 Moreover, S of the conducting plate of L_c=40mm at the frequency where a local maximum of the radiation occurs are shown in Fig.6 as a function of W_c. As can be seen from Fig.5 and Fig.6, the suppression effect of the conducting plate increases as W_c increases and they are converge for W_c >100mm, roughly.

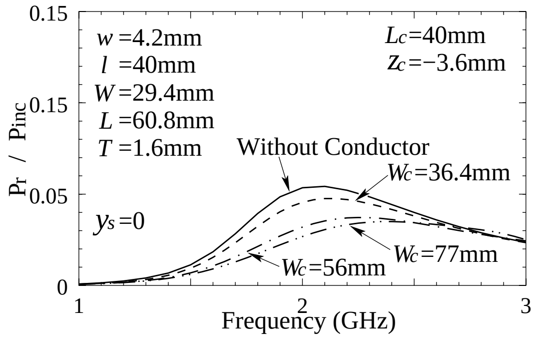

Figure 5: The radiation power from PCB with conducting plate for various W_c

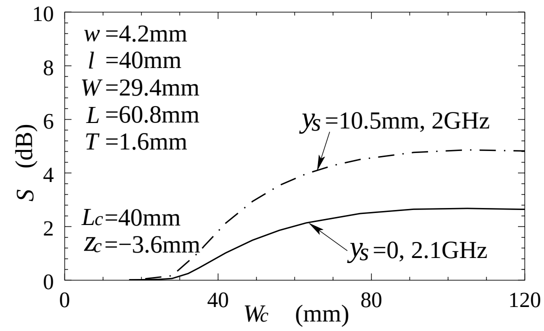

Figure 6: Suppression effect of the conducting plate as a function of W_c

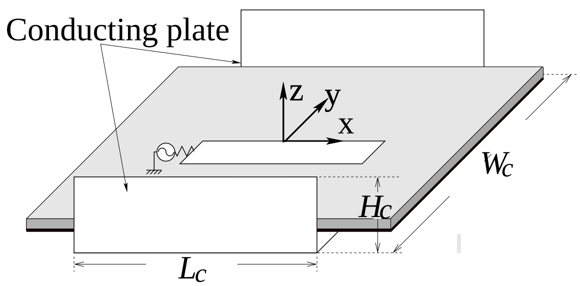

Figure 7: PCB with conducting plate bent its margin

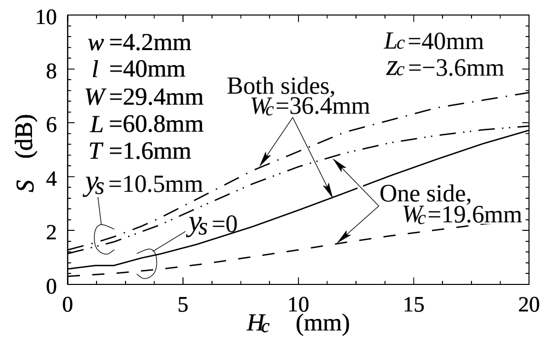

Figure 8: Suppression effect of the conducting plate as a function of H_c

2.3 Numerical Results Using Bent Conducting Plate

In order to miniaturize the conducting plate, the conducting plate which side is bent by H_c is used for suppressing as shown in Fig.7. The suppression effect S using the conducting plate for L_c=40mm at the frequency where a local maximum occurs is shown in Fig.8 as a function of H_c. Here, W_c=36.4mm in the case of bent both sides and W_c=19.6mm in the case of bent one side near the microstrip line. In Fig.8, it describes that the suppression effect increases as the H_c increases in the all cases. Specifically, for y_s=10mm a large suppression effect is obtained not only in the case of bent both sides, but also in the case of bent one side because a large magnetic field intensity occurs near the edge of the PCB for y_s=10mm.

3 Measurement

To validate the calculated suppression effect of the emission from the PCB with a conducting plate using FDTD method, we measure the maximum radiation power from the PCB with or without a conducting plate in the anechoic chamber, as shown in Fig.9. The maximum radiation power is decided in the entire radiation power measured in spectrum analyzer(Agilent E4407B) using the spherical positionar (Device D4661AV2) whose arm moves 90° sector with a broadband horn antenna and the turn table put on the sample PCB turning 360°. To suppress the radiation power from the SMA connector and the semi-rigid cable, we measured only upper half spherical area, the microstrip side, of the PCB.

The measured suppression effect of the conducting plate for L_c=40mm and W_c=56mm is shown in Fig.10 as a function of frequency. It shows that the suppression effect of the conducting plate for y_s=0 is about 1〜2dB and that for y_s=10mm is about 3〜4dB at frequency of 2GHz or less. Then it actually demonstrates the ability to suppress the emission from the PCB using the conducting plate.

In the case using conducting plate bent both sides for H_c=5mm and 20mm, the measured suppression effect of the conducting plate for L_c=40mm and W_c=36mm is shown in Fig.11. It shows that the suppression effect of the bent conducting plate is larger than that of the flat conducting plate for H_c=20mm.

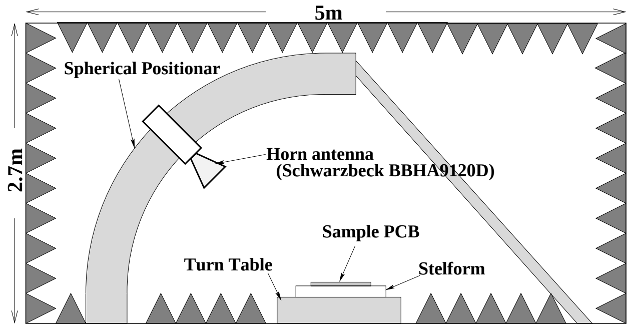

Figure 9: Measurement system of radiation power

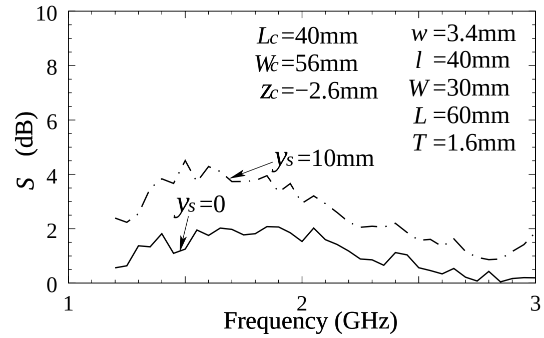

Figure 10: Suppression effect of the conducting plate for L_c=40mm and W_c=56mm

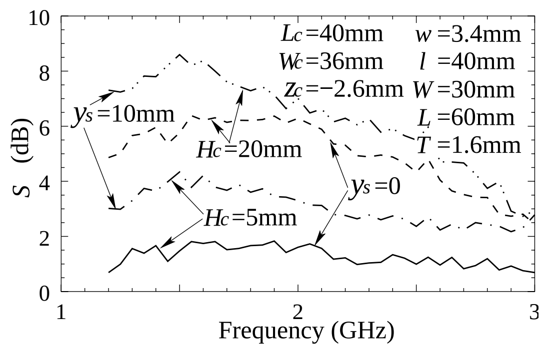

Figure 11: Suppression effect of the conducting plate for H_c=5mm and 20mm(both sides)

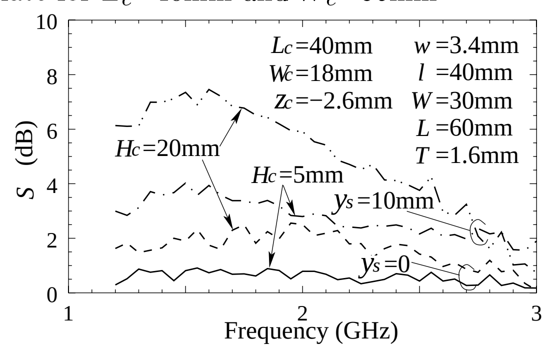

Figure 12: Suppression effect of the conducting plate for H_c=5mm and 20mm(one side)

In the case using conducting plate bent only one side for H_c=5mm and 20mm, the measured suppression effect of the conducting plate for L_c=40mm and W_c=18mm is shown in Fig.12. It shows that relatively the large suppression effect is obtained for y_s=10mm but the suppression effect is small for y_s=0.

4 Conclusion

In order to study the suppression effect of the undesired emission from the PCB using a conducting plate, the radiation power from the microstrip line on the PCB has been calculated by using FDTD method and has been measured. The calculated results have shown that a large suppression effect can be obtained by placing conducting plate bent both side just below the PCB. Also, the measured results show that the numerical analysis is valid.

References

[1] T. Watanabe et al., “Common-mode-current generation caused by difference of unbalance of transmission lines on a printed circuit board with narrow ground pattern, ” IEICE Trans. Commun., vol. E83-B, no. 3, pp. 593-599, March 2000.

[2] A. Sakurai et al., “Resonance Frequency Variation with a Nearby Floated Metal Plate, ” IEICE Trans. Commun., vol. E83-B, no. 3, pp. 555-560, March 2000.

[3] K. S. Kunz and R. J. Luebbers, *The Finite Difference Time Domain Method for Electromagnetics*, CRC Press, 1993.

[4] J. P. Berenger, “A perfectly matched layer for the absorption of electromagnetics waves,” Journal of Computational Physics, vol. 114, no. 1, pp. 185-200, 1994.