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A Study of Diversity Antenna mounted on PC Card with Slit

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1. Introduction

Wireless LAN systems employ diversity antennas for reducing multipath fading. This paper describes the diversity characteristics of small antennas for radio terminals. When several antennas are provided in the vicinity, the correlation coefficient between diversity antennas often increases and the radiation efficiency decreases by mutual coupling between antennas.

A method to improve the correlation coefficient among the antenna elements by mutual coupling between antenna elements has been reported [1]. However, this leaves the problem of a decrease in the radiation efficiency. Measures are needed to improve the correlation coefficient without reducing the radiation efficiency.

In this paper, we propose a new method in which a slit is provided on a finite ground plane with antennas to control the current on the finite ground plane and improve the correlation among antenna elements. A slit is a useful measure for improving the correlation coefficient. In the case of a small antenna, the current on the finite ground plane is superior to the current on the antenna elements in radiation, because the finite ground plane which operates as an antenna element has a larger radiation resistance than that of a small antenna. When a slit is provided on the ground plane to change the ground plane to an asymmetric structure, the current distribution on the ground plane is changed asymmetrically. Therefore, this asymmetric distribution causes differences between antennas and a pattern diversity effect is achieved. This diversity effect improves the correlation coefficient without applying mutual coupling. Additionally, the radiation efficiency does not decrease because mutual coupling is not applied.

2. Antenna Configuration

Figure 1 shows the schematic view of the proposed diversity antenna. The proposed diversity antenna consists of two inverted F antennas and the finite ground plane with the slit. Where l is the distance from the side of the finite ground plane with two antennas, d is the depth of the slit and w is the width of the slit.

Figure 2(a) shows the schematic diagram of the current distribution on a finite ground plane without a slit. The current distribution shown in Fig. 2(a) is symmetrical. When a slit is provided on a finite ground plane, the current distribution on the finite ground plane is changed asymmetrically as shown in Fig. 2(b). Therefore, the radiation pattern of antenna 1 changes significantly and a pattern diversity effect is achieved. This diversity effect improves the correlation coefficient.

Numerical Electromagnetic Code 2 (NEC2) is used in order to calculate the radiation efficiency and radiation pattern. The non-selected antenna is terminated with a 50 ohm load in order that the diversity antenna is used for combination or selection diversity.

3. Calculation Results

We have calculated the correlation coefficient among two antennas, the radiation efficiency and the radiation pattern. The radiation efficiency is calculated in order to determine the degree of coupling between two antennas. The correlation coefficient ρ is calculated as follows:

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$$\rho = \frac{\int_{-\pi}^{\pi} G_1^*(\phi)G_2(\phi)P(\phi)e^{-j2\pi d\cos\phi/\lambda}d\phi}{\left[\int_{-\pi}^{\pi} G_1^*(\phi)G_1(\phi)P(\phi)d\phi \cdot \int_{-\pi}^{\pi} G_2^*(\phi)G_2(\phi)P(\phi)d\phi\right]^{1/2}} \qquad (1)$$

where G_i is the radiation pattern of each antenna calculated by NEC2, P is the multiple incoming wave to the diversity antenna, d is the distance between two antennas, λ is the wavelength and this coordinate system is the polar coordinate system. The multiple incoming wave used here is a uniform distribution wave.

Figure 3 shows the radiation efficiency of antenna 1 and the correlation coefficient between two antennas when l is 6/50 λ and d is varied from 0 λ to 13/50 λ. As shown in Fig. 3, providing a slit on the finite ground plane increases the radiation efficiency of antenna 1, and decreases the correlation coefficient. The correlation coefficient is 0 around d = 8/50 λ, and the radiation efficiency is nearly 100% at d = 8/50 λ. This shows that both the correlation coefficient and the radiation efficiency improve at the same time.

Figure 4 shows the radiation pattern of antenna 1 and antenna 2 at l = 6/50 λ and d = 8/50 λ. Figure 5 shows the radiation pattern of antenna 1 and antenna 2 without a slit on the finite ground plane. In comparison with the radiation pattern of antenna 1 in Figs. 4 and 5, it is obvious that the radiation pattern of antenna 1 in Fig. 4 is significantly different from that in Fig. 5. The radiation patterns of both antenna 1 and antenna 2 cover null point of the other radiation pattern. Therefore, a sufficient pattern diversity effect is achieved, and the diversity effect improves the correlation coefficient. Regarding the improvement in the radiation efficiency, it is considered that the pattern diversity effect reduces the coupling between the two antennas.

Figures 6 and 7 show the correlation coefficient and the radiation efficiency respectively when d is varied from 0 λ to 13/50 λ while varying distance l. These results are similar to that when l = 6/50 λ, and the correlation coefficient and radiation efficiency are improved while varying distance l by verifying depth d. When the position of the slit is close to antenna 1, there is a wide range that improves both the correlation coefficient and the radiation efficiency. Therefore, this diversity antenna is easy to design when the slit is close to antenna 1.

4. Conclusion

This paper has proposed a diversity antenna composed of two inverted F antennas and the finite ground plane with a slit. This proposed diversity antenna has the slit in order to control the current on the finite ground plane. By the slit, the current distribution on the finite ground plane is changed and the pattern diversity effect is achieved. Therefore the correlation coefficient and the radiation efficiency improve at the same time.

The realization of improvement in the correlation coefficient and the radiation efficiency suggest that the capacity of transmission is improved. Hence, it is clear that the proposed diversity antenna is suitable for the diversity antenna used for wireless LAN.

References

[1] K. Sawaya, T. Ishizone, Y. Musiake, Proceedings of the 1982 IEICE General Conference, 3-610.

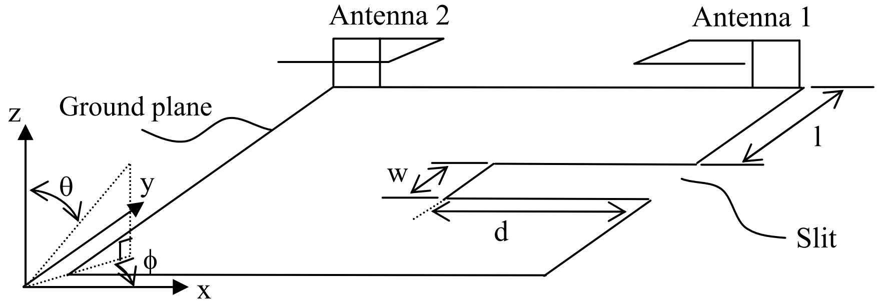
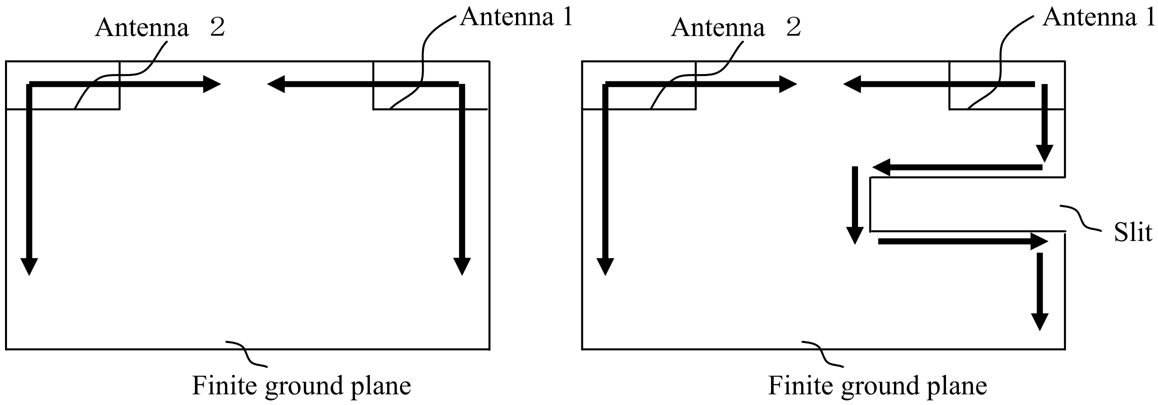


Figure 1: Geometry of diversity antenna composed of two antennas and ground plane with a slit.



(a) Symmetrical structure. (b) Asymmetrical structure.

Figure 2: Schematic diagram of current on the finite ground plane.

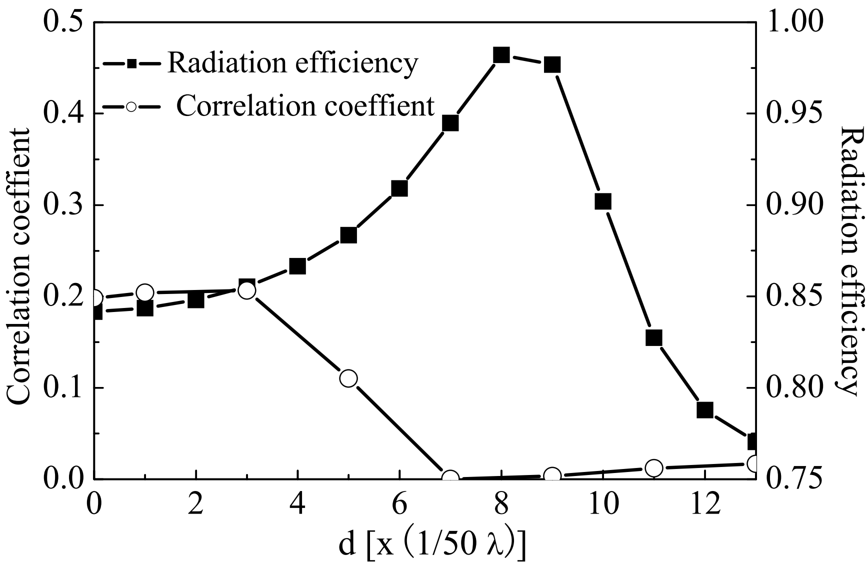
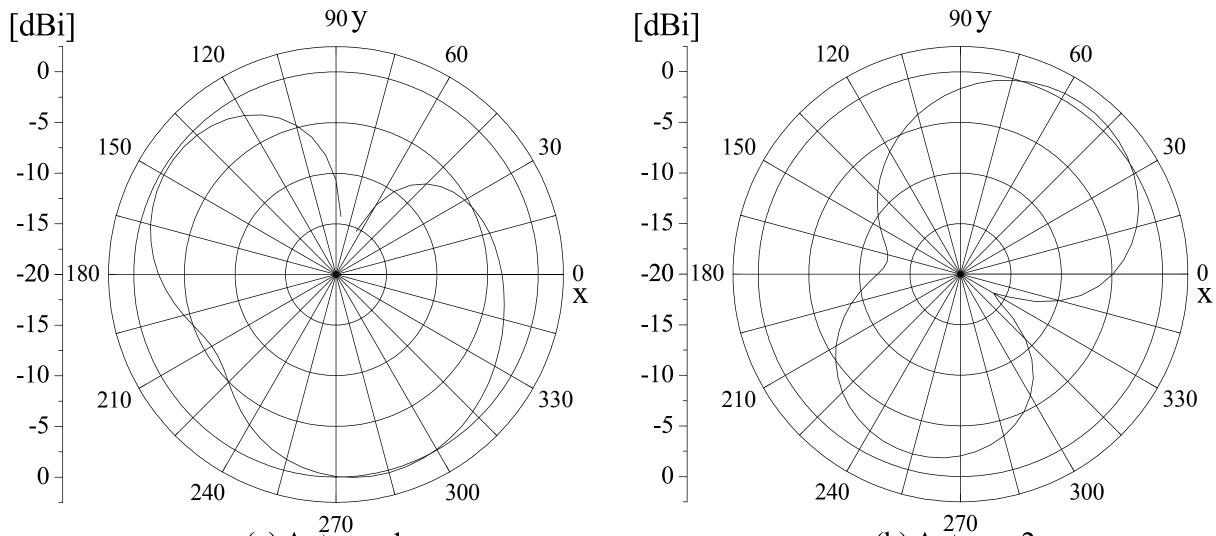
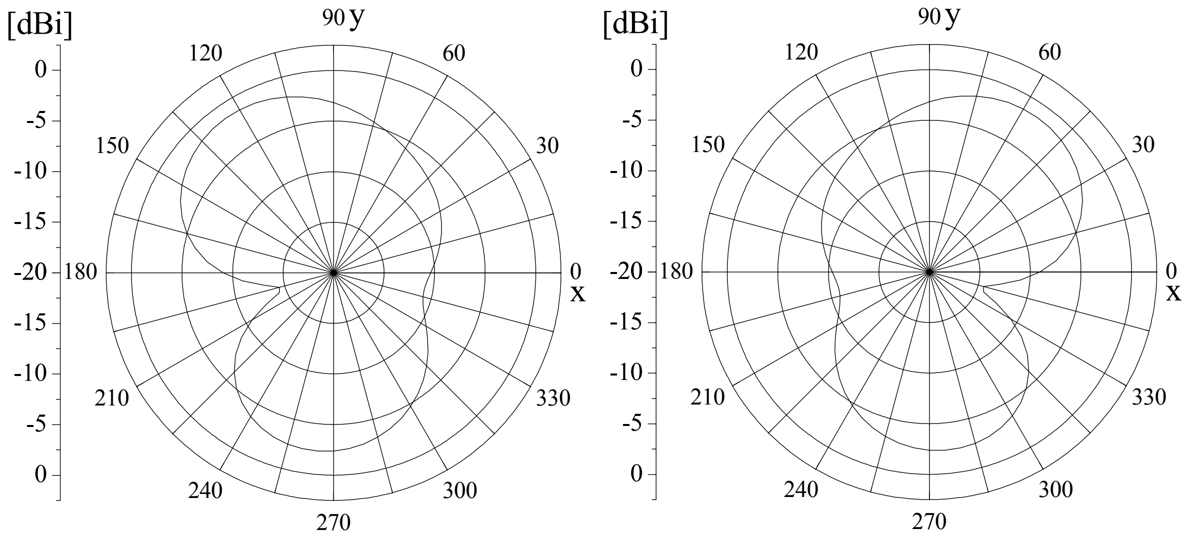


Figure 3: Radiation efficiency of antenna 1 and the correlation coefficient between two antennas at l = 6/50λ and d = 8/50λ.



(a) Antenna 1 (b) Antenna 2

Figure 4: Radiation pattern of two antennas with the slit (l = 6/50λ and d = 8/50λ).



(a) Antenna 1 (b) Antenna 2

Figure 5: Radiation pattern of two antennas without a slit.

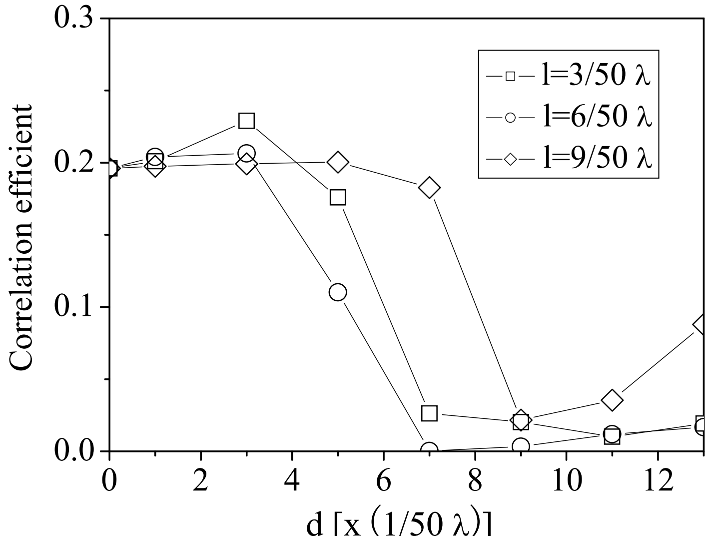


Figure 6: Correlation efficient between two antennas at position l of the slit.

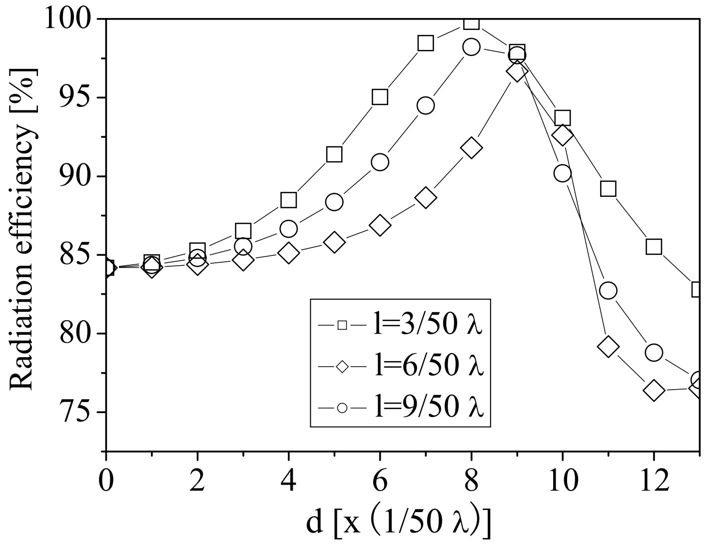


Figure 7: Radiation efficiency of antenna 1 at position l of the slit.