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A STUDY OF PLACEMENT AND COMBINATION OF TWO ANTENNAS ON ELECTRICALLY SMALL GROUND PLANE

Yuji NAKAYAMA†, Hiroyuki ARAI†, and Kohei MORI‡
†Department of Electrical and Computer Engineering, Yokohama National University
79-5 Tokiwadai, Hodogaya-ku, Yokohama-shi 240-8501, Japan.
E-mail: nakayama@arailab.dnj.ynu.ac.jp
‡Semiconductor Solutions Network Company, Sony Corporation
4-14-1 Asahi-cho, Atsugi-shi 243-0014, Japan.

1 Introduction

Antenna diversity for handset terminals is used to reduce the effects of multipath fading. To achieve high diversity gain, it is necessary to obtain a low correlation coefficient for diversity antennas, and various combinations of antennas have been considered. Paralleled two dipole antennas mounted on a metal body [1] has a low correlation coefficient by deformed pattern due to mutual coupling of antennas. A combination of whip antenna and planar inverted-F antenna (PIFA) mounted on a metal body [2] was also investigated to obtain low correlation coefficient by changing the antenna parameters (metal body length, whip length, setting point of PIFA, and so on). These models under real propagation environment have reasonable correlation coefficient, however, their ground plane is a straight type. Recently a popular handset terminal is clamshell type and its closed position has very small electrically ground plane. Therefore, a novel antenna placement is required for electrically small ground plane.

This paper presents basic investigation for correlation coefficient of the placement of two antennas on electrically small ground plane for an application of clamshell type terminal. Using monopole and dipole antennas, an optimum antenna placement is investigated by calculating correlation coefficient.

2 Monopole Antenna Placement

Ground plane model used in this paper is shown in Fig.1. Two metal plates ($0.18\lambda \times 0.09\lambda$) are connected with polyimide ($\epsilon_r = 3.4$), assuming a flexible substrate. This ground plane model is a mockup of small clamshell type handset. This model has two conditions, being (i) closed and (ii) open, in the frequency band of 2GHz.

Figure 2 shows model A, in which two monopole antennas are placed on the ground plane. Two antenna placements are (a) parallel and (b) orthogonal as shown in Fig.2, respectively. Each model is examined for two types of ground plane, and correlation coefficients of four cases are calculated by the same procedure in ref [3]. Antenna radiation pattern is calculated by CST Microwave Studio Ver.5. Correlation coefficient of each model as a function of antenna spacing is shown in Fig.3. Correlation coefficient of model A-(b) is smaller than model A-(a) for small antenna spacing d $\leq 0.04\lambda$, which indicates the orthogonal antenna placement is very effective to obtain small correlation coefficient. On the other hand, the correlation coefficient of model A-(a) becomes small for antenna spacing d $\geq 0.04\lambda$, because radiation patterns of two monopole antennas become different each other by the mutual coupling. In xy plane, radiation patterns of model A-(b) of $d = 0.013\lambda$ and $d = 0.052\lambda$ are shown in Figs. 4 and 5. Both radiation patterns of $d = 0.013\lambda$ are almost the same, however, radiation patterns of $d = 0.052\lambda$ are different each other by the mutual coupling. There is no difference in correlation coefficient for the condition of ground plane, closed or open.

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3 Combination of Monopole and V-dipole

Correlation coefficient of orthogonal placement model is almost 0.4, however, it is better to obtain smaller correlation coefficient to achieve high diversity gain. The current distribution of model A-(b) is shown in Fig.6. The current is strongly distributed on the ground plane. The current of ground plane is concentrated in space between two antennas, then it causes strong mutual coupling and increases correlation coefficient. We change one monopole antenna for a dipole antenna, because the current distribution on ground plane is rather small for dipole antenna. To obtain good impedance matching, dipole antenna is bent at the center, called a V-dipole antenna.

Figure 7 shows the antenna placement of model B, in which monopole antenna and V-dipole antenna are on the ground plane. Feed model of V-dipole antenna is a gap feed, and a space between ground plane and V-dipole antenna is about 0.5 mm. Two antenna placements are (a) parallel and (b) orthogonal as shown in Fig.7, respectively. The case (a) and (b) are defined by the feeding voltage vector as shown in Fig.7. Each model is examined for two types of ground plane. Correlation coefficient of each model as a function of antenna spacing is shown in Fig.8. Correlation coefficient of model B is smaller than model A, which indicates the combination of monopole and V-dipole is very effective to obtain small correlation coefficient. In xy plane, radiation patterns of model A and model B are shown in Figs. 9 and 10. The condition of this comparison is for closed type, orthogonal feed and $d = 0.031\lambda$. Radiation patterns of model A are similar, because the current of ground plane is concentrated in space between two antennas. On the other hand, radiation patterns of model B are different each other, because the current is hardly distributed on the ground plane and only antenna feed. Correlation coefficient of model B-(b) is smaller than model B-(a), which shows the orthogonal antenna placement is very effective to obtain small correlation coefficient in an electrically small ground plane. There is no difference in correlation coefficient for the condition of ground plane, closed or open.

4 Conclusion

In this paper, we considered antenna placement to obtain low correlation coefficient on the small ground plane. When two monopole antennas were placed on the ground plane, we indicated the orthogonal antenna placement was very effective to obtain small correlation coefficient for small antenna spacing d $\leq 0.04\lambda$. When monopole antenna and V-dipole antenna were placed one the ground plane, we indicated the combination of monopole and V-dipole was very effective to obtain small correlation coefficient.

In future, we need to downsize antennas for useful size, because this paper presented basic investigation. And, it is necessary to calculate correlation coefficient under real propagation environment and to do experiment.

References

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[3] N. Kuga, H. Arai, "Planar Multi-Sector Beam Antenna, "IEICE General Conference, SB-1-8, March 1997.

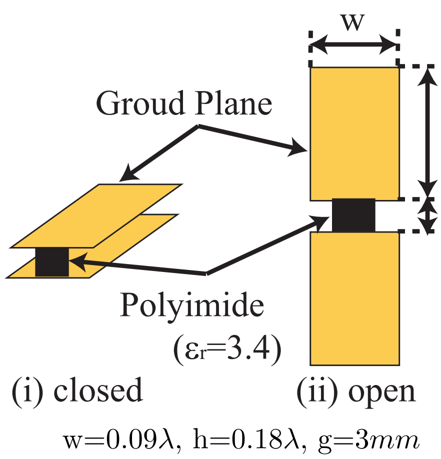

Figure 1: Ground Plane Model

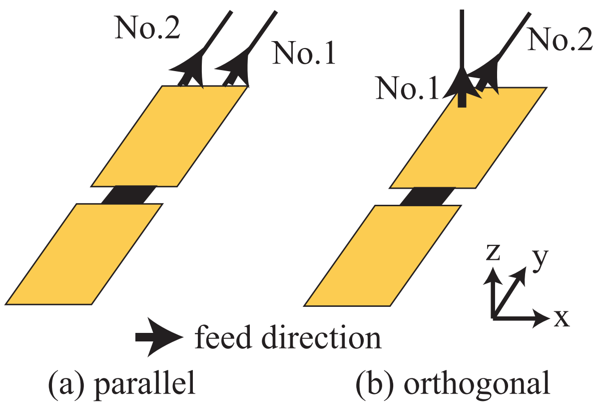

Figure 2: Model A

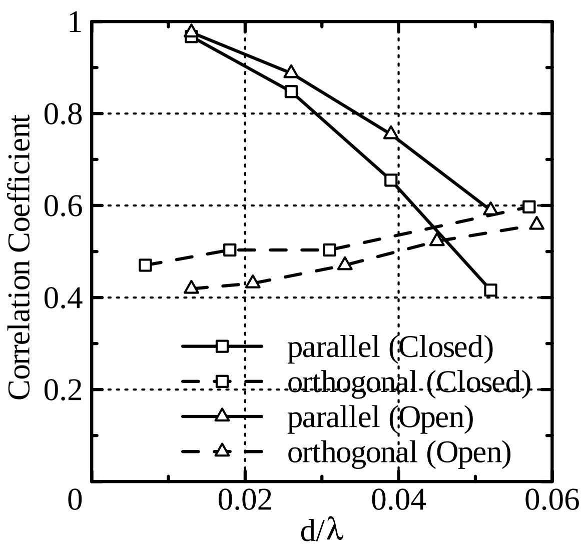

Figure 3: Correlation Coefficient of Model A

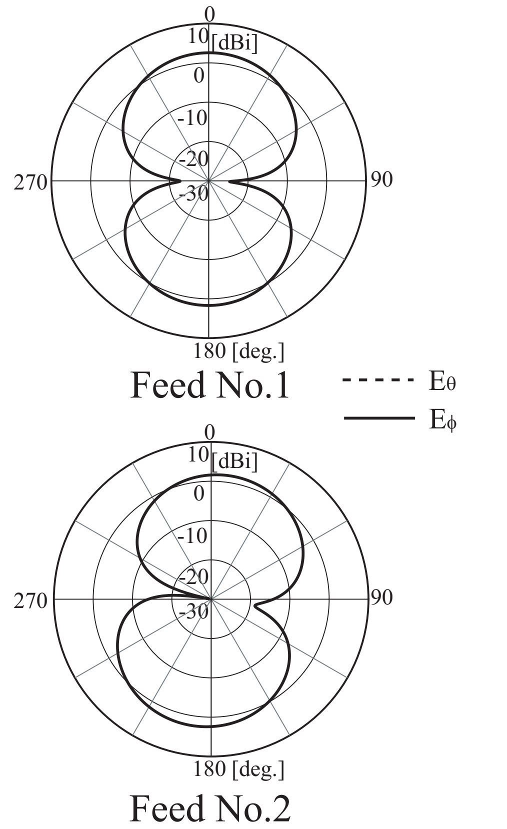

Figure 4: Radiation Pattern of d/λ=0.013

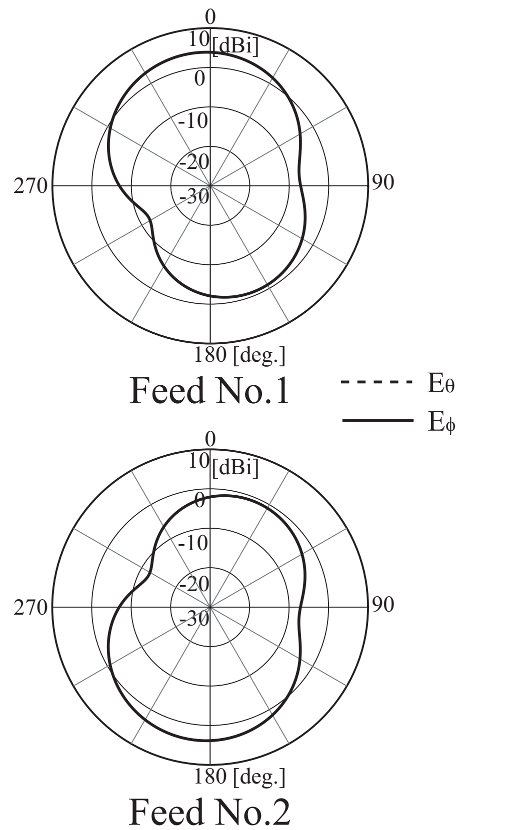

Figure 5: Radiation Pattern of d/λ=0.052

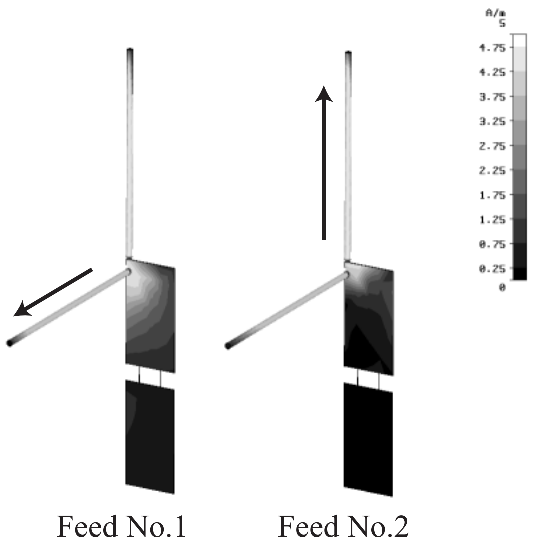

Figure 6: Current Distribution

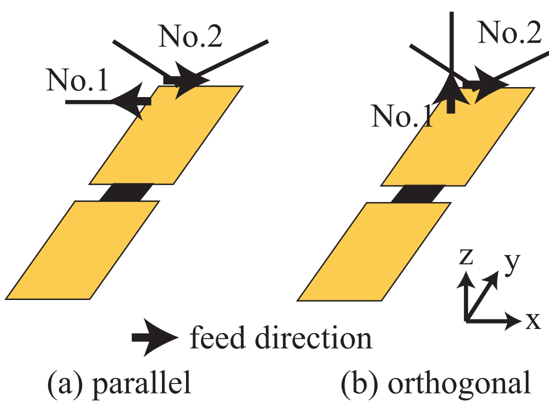

Figure 7: Model B

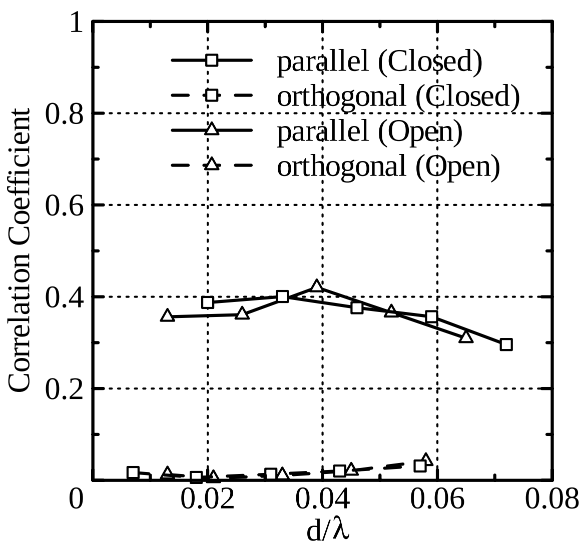

Figure 8: Correlation Coefficient of Model B

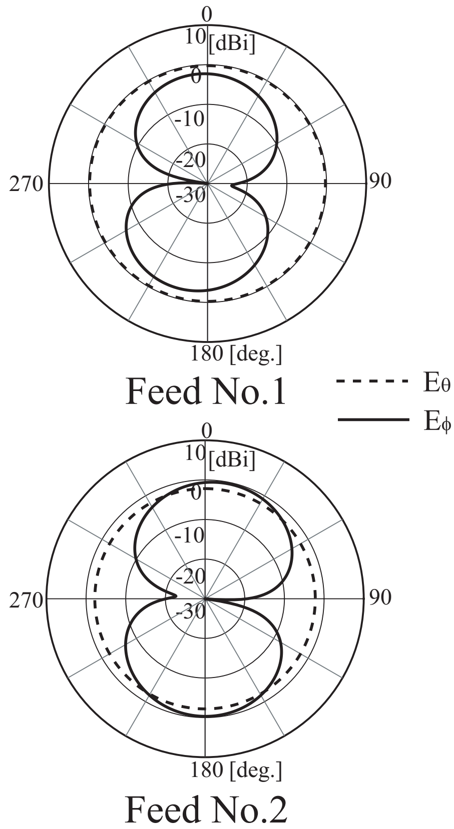

Figure 9: Radiation Pattern of Model A-(b)

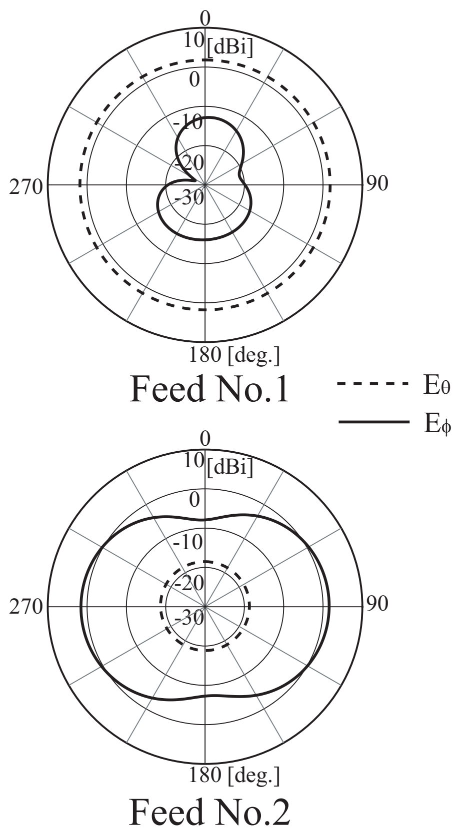

Figure 10: Radiation Pattern of Model B-(b)