Reduction of Mutual Coupling for Diversity Antenna with Folded Parasitic Element

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1. Introduction

Wireless LAN systems employ antenna diversity for reducing multipath fading. When several antennas are closely mounted, the radiation efficiency usually decreases due to mutual coupling between the antennas.

Several methods to reduce mutual coupling between antennas have been reported [1]-[3]. These methods require too much space for them to be applied in a cellular phone or a mobile terminal. In Reference [3], a slit is used in the ground plane to change the current distribution on the ground plane and then the mutual coupling between the antennas decreases. It is usually difficult to make a slit in the ground plane, because the circuit components are mounted on the same ground plane where a diversity antenna is installed. Measures suitable for a cellular phone or a mobile terminal are needed to improve the radiation efficiency.

In this paper, we propose a new method in which a folded parasitic element is introduced on a finite ground plane to control the current on the ground plane and to improve the radiation efficiency.

2. Basic Principle

A folded parasitic element is a useful measure for reducing mutual coupling between antennas. When the antenna on an edge of the finite ground plane is fed, the current on the edge of the finite ground plane is generally larger than the other part on the finite ground plane. This large current causes the mutual coupling between antennas on the edge of the finite ground plane. When a folded parasitic element is provided between two antennas on the edge of the finite ground plane, the folded parasitic element acts as a choking stub to reduce the current on the edge of the finite ground plane. As a result, the coupling between antennas decreases and the radiation efficiency is expected to increase.

3. 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 folded parasitic element between the two antennas. Where l is the length in the direction of y axis, h is the height from the finite grand plane, and w is the width of folded parasitic element. This diversity antenna is symmetric with respect to the dashed line in Figure 1. Antennas 1 and 2 are connected to each terminator with 50 Ω.

4. Calculation Results

We have calculated the radiation efficiency and the coupling between two antennas. Numerical Electromagnetic Code 2 (NEC2) is used for calculation of the radiation efficiency and radiation pattern of Antenna 1. The coupling $|S_{21}|$ between Antenna 1 and Antenna 2 is calculated as follows:

$$\left|S_{21}\right| = 10\log(P_{Loss} / P_{in}) \quad (1)$$

where P_{Loss} is the power consumption in the 50 ohm termination on Antenna 2, and P_{in} is the input power to the selected antenna.

Figure 2 shows the radiation efficiency of Antenna 1 and $|S_{21}|$, varying the height h under the condition that the total length of the folded parasitic element ($2(h+l)+w$) is kept at λ/2. The width w has a constant value, λ/50. A larger value of h shows a smaller $|S_{21}|$ and a larger radiation efficiency of Antenna 1 if h is larger than 0.1 λ. But at the height h of 0.08 λ, $|S_{21}|$ is maximum value and larger than that without the folded parasitic element in spite of the folded parasitic element acting as a choking stub. Therefore, the characteristics at the height h of 0.08 λ are analyzed in detail, varying the length l in the direction of y axis, as follows.

Figure 3 shows the radiation efficiency of Antenna 1 and $|S_{21}|$ for changing the length l from 0.02 λ to 0.25 λ with the height h and width w of 0.08 λ, λ/50 respectively. $|S_{21}|$ is maximum and the radiation efficiency is minimum at the length l of 0.14 λ. $|S_{21}|$ is minimum and the radiation efficiency is maximum at the length l of 0.17 λ . It is observed in the simulation result that the folded parasitic element acts as a choking stub at the length l of 0.17 λ and the current on the edge of the ground plane is decreased.

Figure 4 shows the impedance characteristic of the folded parasitic element at the height h of 0.08 λ, varying the length l. The reactance is 0 around the length l of 0.15 λ. In this condition, the folded parasitic element tends to be resonated, and Antennas 1 and 2 are coupled via the folded parasitic element. Figure 5 shows the radiation efficiency of Antenna 1 in the case of the optimization with the length l for each height h. The radiation efficiency is improved at each height h compared with the result without the folded parasitic element. In the case of a mobile terminal, the height h influences the mobile terminal thickness. The optimum height h is determined by the space for the diversity antenna. Figure 6 shows the total length of the folded parasitic element optimized with the length l at each height h. The total length of the folded parasitic element is longer than λ/2 and varies according to the height h.

VSWR characteristic of antenna 1 in the case of optimization with the length l at desired frequency band is 2 or less, and thus the antenna operates properly.

5. Conclusion

This paper proposed a diversity antenna composed of two inverted F antennas and the finite ground plane with a folded parasitic element in order to improve the radiation efficiency. The folded parasitic element on the edge of the finite ground plane between two antennas acts as a choking stub and can decrease the current induced on the edge of the finite ground plane.

It is found that the radiation efficiency degrades when the folded parasitic element tends to be resonated. The optimization of the length of the folded parasitic element was performed. After the optimization of the height and the length of the folded parasitic element, the coupling between two antennas decreases and the radiation efficiency increases. The optimized total length of the folded parasitic element is longer than λ/2 and varies according to the height from the ground plane.

The proposed diversity antennas would provide a larger link gain and will be suitable for wireless LAN.

References

[1] Samuel C. K. Ko and Ross D. Murch, “Compact Integrated Diversity Antenna for Wireless Communications,” IEEE Trans. Antennas Propagat., vol. 49, pp. 954-960, June 2001.

[2] Naoki Honma et al., “Proposal of Compact Three Port MIMO Antenna Employing Modified Inverted F antenna and Notch Antenna,” Proc. IEEE AP-S Int. Symp., Jul. 2006, pp. 2613-2616.

[3] Takafumi Ohishi et al., “A method to improve the correlation coefficient and the mutual coupling for diversity antenna,” Proc. IEEE AP-S Int. Symp., Jul. 2005, Vol. 1A, pp. 507-510.

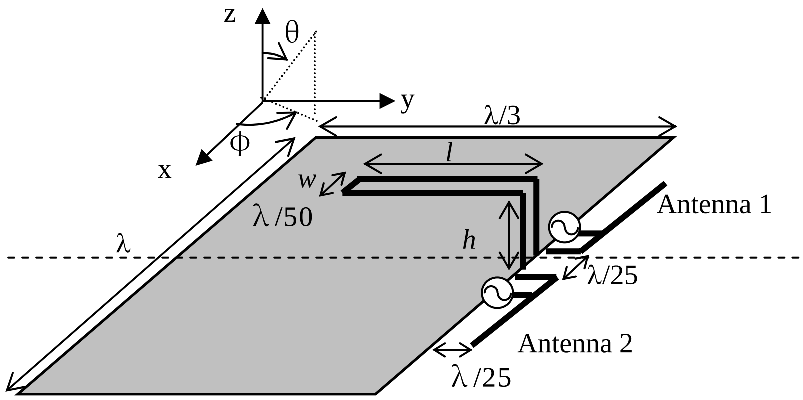

Figure 1: Geometry of diversity antenna composed of two antennas and ground plane with a folded parasitic element.

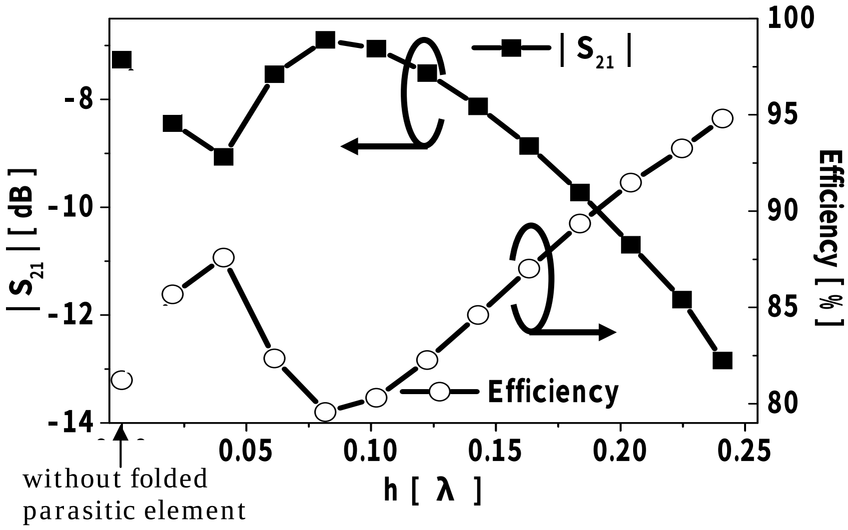

Figure 2: Radiation efficiency of Antenna 1 and $|S_{21}|$.

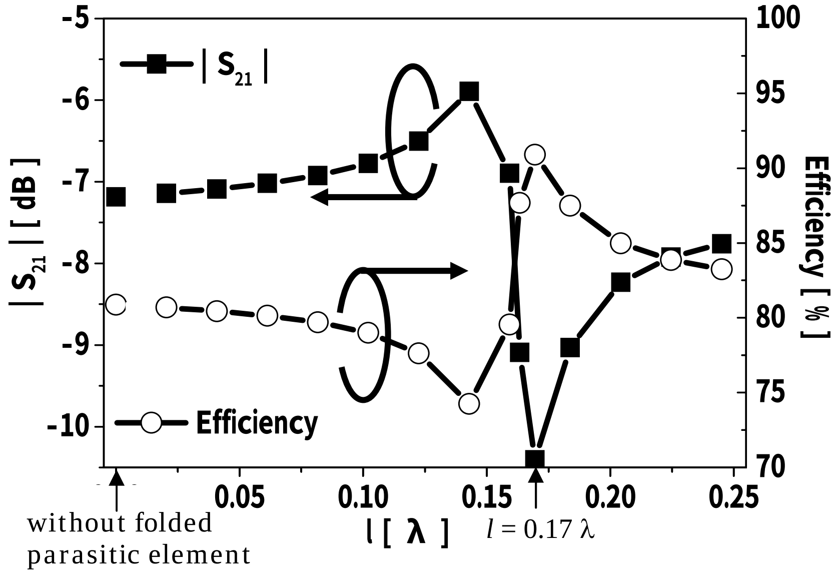

Figure 3: Radiation efficiency of Antenna 1 and $|S_{21}|$ at $h = 0.08\ \lambda$, varying l.

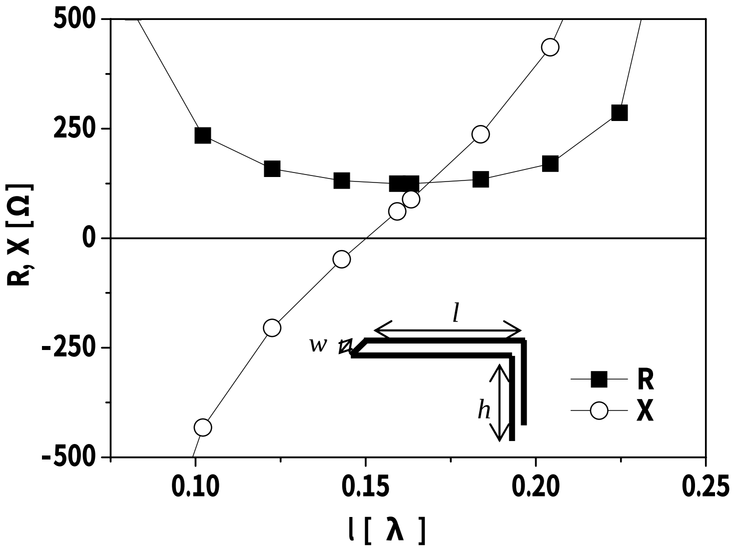

Figure 4: Impedance characteristic of folded parasitic element at h = 0.08 λ, varying l.

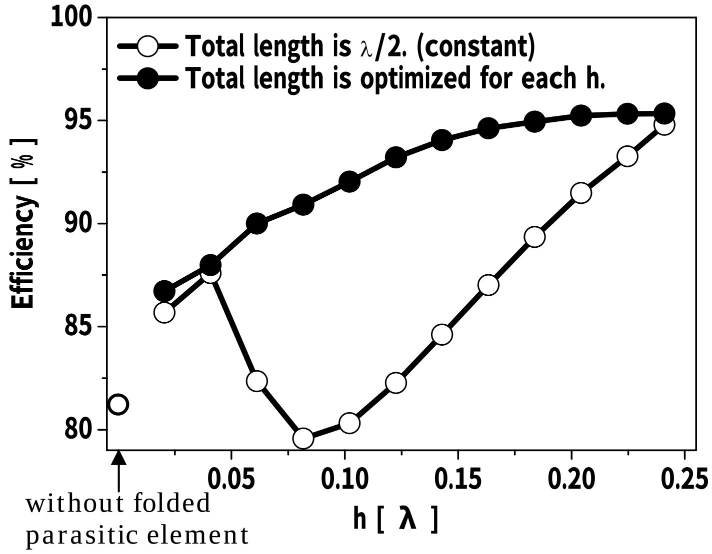

Figure 5: Radiation efficiency of Antenna 1 after optimization with length *l*.

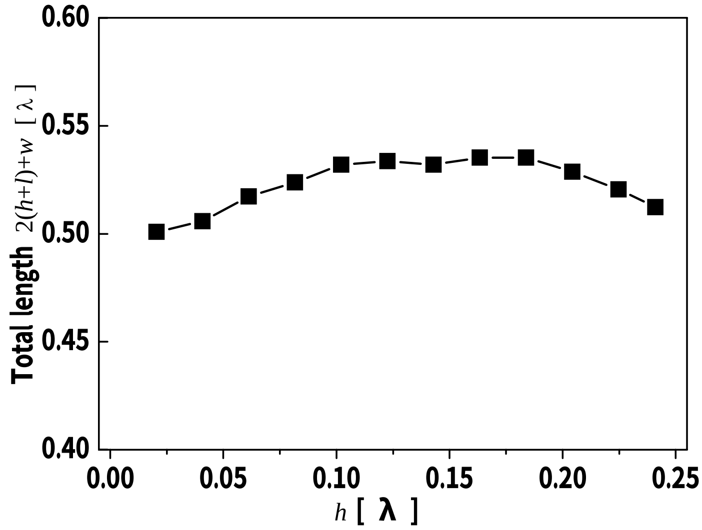

Figure 6: Total length of folded parasitic element optimized with respect to radiation efficiency for each height *h*.