DESIGN FOR NOVEL MIMO ANTENNA WITH LOW MUTUL COUPLING

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1. Introduction

In recent years, there are lots of studies on MIMO antenna system for mobile communication or W-LAN system, etc.; because the MIMO antenna system is suitable candidate for 4th generation mobile communication required high speed, large quantity and high quality. In spite of these advantages, the MIMO antenna system has a serious problem caused by strong mutual coupling between antenna elements. Mutual coupling makes signal interference between each antenna element. This problem caused by the mutual coupling between antenna elements is difficult to solve using baseband algorithm and signal processing[1]. Recently, many studies devoted to suppress the mutual coupling between antenna elements. Since they have been considered only the software approaches like baseband algorithm or DSP, its embodiment is difficult. To solve this problem more effectively, it must be considered the mutual coupling in hardware including antenna. There are a few studies on considering the mutual coupling in antenna system; for example, antenna with boxy metallic wall[2], antenna using absorber[3], etc. They used the 3-dimension structures for suppress the mutual coupling, so they have complex and big structure. This paper investigates a rectangular array antenna for mutual coupling suppression using 2-dimension structure with 4 parasitic elements consisted of microstrip line. The key point of this paper is antenna design with low mutual coupling among the each antenna element with consideration for the independent channel operation in the MIMO system.

2. 4-channel antenna design for MIMO system

A single patch antenna is designed for a MIMO antenna system as shown in Fig.1[4]. Center frequency of the single patch antenna is assumed that satisfy 5 GHz band proposed from IEEE 802. 11a. The miniature patch antenna proposed in this paper employs 5 mm air substrate for broad bandwidth and gap feed with via hole for miniature size of the antenna[5]. Fig. 1 shows the design structure and specification of a proposed patch antenna. To achieve the suppression of mutual coupling with gap feeding, firstly, 4-patch array antennas as a patch antenna of reference[2] proposed by our group are designed. Fig. 2 shows a configuration of the patch array antennas. Even though each antenna element has a same size and structure as an array antenna, each element is designed and operated independently to

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realize the MIMO antenna system. These elements are arrayed by half wave length interval for both of latitude and longitude direction. Fig. 2 shows the fabricated 4-channel patch array antennas. As shown in Fig. 3, the return loss of 4-channel patch antenna is observed -10 dB below at W-LAN band and it has almost same values comparing with simulation(Fig. 4). The measured mutual coupling for each channel such as S21, S31 and S41 of this antenna is about -20 dB at 5.15 GHz ~ 5.35 GHz and the antenna gain of each element is about 6.5 dBi at 5.25 GHz. Fig. 5 (a) and (b) show the measured and the calculated radiation patterns of each element operated as independent channel in the MIMO antenna system, respectively. The measured patterns are observed reasonable agreement with the calculated ones.

3. Novel design for low mutual coupling

To suppress mutual coupling between elements, it is considered the parasitic elements which is composed of microstrip line. Parasitic elements are used as resonant elements. In horizontal direction, two parasitic microstrip lines are employed. As shown in Fig. 6, the mutual coupling is changed according to the number of parasitic elements(Fig. 6(a)) and the length of parasitic elements(Fig. 6(b)). In Fig. 6 (a), the mutual coupling values of 2 and 3 parasitic elements are lower than that of one parasitic element. Therefore, 2 parasitic elements are considered to suppress the mutual coupling in this design. When two parasitic elements which have length of 16.55 mm are located on between two antenna elements, the mutual coupling between two antenna elements is suppressed about -40 dB below at 5.25 GHz band. Fig. 6 (b) shows the variation of parasitic element length. By changing of its length, frequency is also shifted and the optimum value is also changed. Therefore, the length of 16.55 mm is adopted in design. In case of vertical direction, a parasitic element with same direction is employed to suppress mutual coupling forward vertical direction. As shown in Fig. 7, it shows similar phenomenon to the horizontal direction. Thus, it is able to control the mutual coupling using one parasitic element. Fig. 7 (a) and (b) show variation of S-parameters according to offset and length of parasitic elements. Mutual coupling and return loss are changed according to offset and length of parasitic element, respectively. When a parasitic element which has length of 37.5 mm and offset of 15 mm is placed between two antenna elements, the mutual coupling is suppressed about -40 dB below at 5.25 GHz band. Fig. 8 shows current distributions of the proposed antenna with parasitic elements. As shown in Fig. 8 (a), when only #1 element is fed, currents flow through antenna and parasitic elements, and in Fig. 8 (b), when #1 and #2 elements are fed simultaneously, the interference currents are cancelled by the parasitic elements located on the horizontal direction. The currents distribution of #1 and #2 elements is realized the same pattern. Because surface wave between #1 and #2 antenna elements is cancelled by the horizontally located parasitic elements, the mutual coupling between two elements is strongly suppressed. As shown in Fig. 8 (c) and (d), the current characteristics of vertical array show the similar phenomenon such as the result of Fig.8 (a) and (b) for the vertically located parasitic elements.

4. Conclusion

This paper presents a possibility of mutual coupling suppression between patch antenna using parasitic elements to realize an independent channel for MIMO antenna system. 4-channel patch antenna without parasitic elements is confirmed about -20 dB mutual coupling. However, if parasitic elements are employed, it will be remarkably realize to reduce mutual coupling between each antenna element. Since most of the previous researches have been used 3-dimension structure for mutual coupling suppression, they have complex structure. However, the novel design proposed in this paper shows only 2-dimension structure. Therefore, this design structure has both advantages that it can reduce the entitle size and suppress the mutual coupling between MIMO antenna elements, effectively. Mutual coupling of 4-channel MIMO antenna with independent operation is suppressed about -40 dB below by the parasitic elements.

Acknowledgement

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References

[1]Sung Jin Kim, Yong Suk Lee, Ho Jin Kim, Hyeon Woo Lee, "Technical Review for 3GPP Downlink Multiple Antenna Conceptes." Telecommunication Review, vol. 12, NO. 2 pp. 152-168, Mar. 2002.

[2]Yuki INOUE, Hirotake SUMI, Hiroyuki ARAI, "Pattern Calibration Free Antenna by Suppressing Mutual Coupling Between Elements." Proceeding of ISAP 2004

[3]Tae Yoon Lee, Nak Sun Sung, Ji Hun Bae, Chul Sik Pyo, Jong Suk Chae, "Planar Microstrip Array Antenna", Korea Patent, Registration No. 10-2002-0074683, Nov. 2002.

[4]Kyeong Sik Min, Dong Jin Kim, "Patch Array Antennas for Home Network System", KJJC, Nov. 2004.

[5]D.Sanchez-Hernandez and I. D. Robertson, "A survey of broadband microstrip patch antennas," Microwave J, pp. 60-64, Sept. 1996.

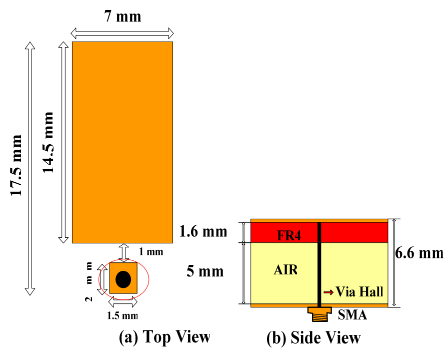


Fig. 1 Single patch antenna.

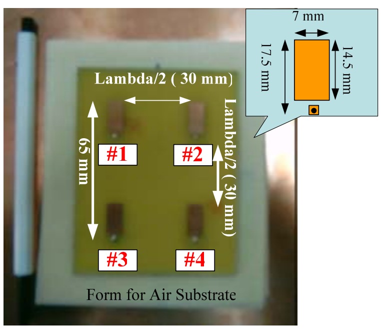


Fig. 2 Design specification of the fabricated patch array antennas.

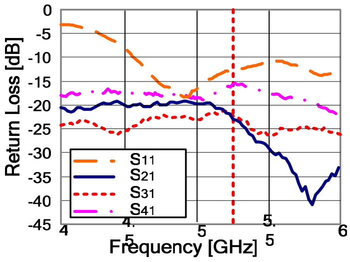


Fig. 3 Measured S-parameters of the MIMO antenna without parasitic elements.

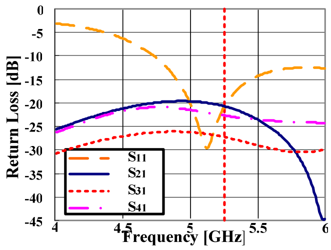
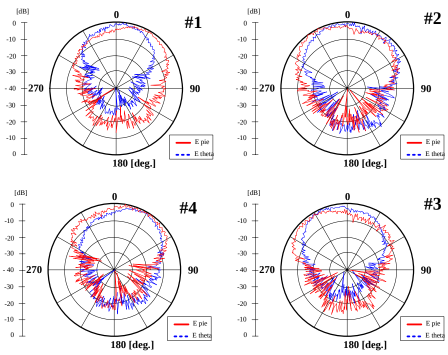
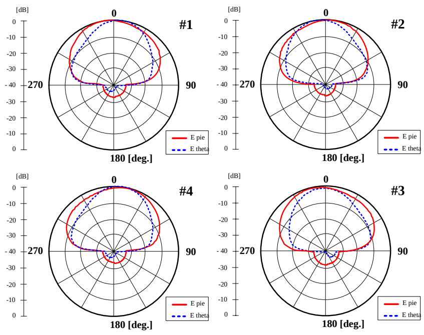


Fig. 4 Calculated S-parameters of the MIMO antenna without parasitic elements.

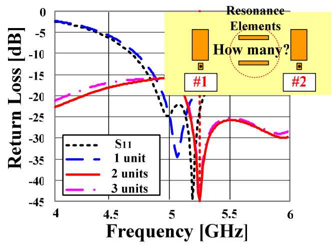


(a) Measured radiation patterns

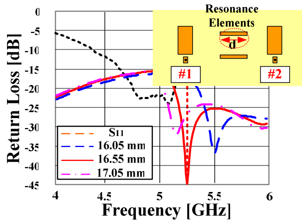


(b) Calculated radiation patterns

Fig. 5 Measured radiation patterns of MIMO antenna.

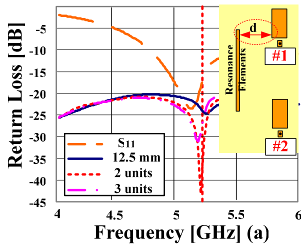


(a) Change of the parasitic elements number.

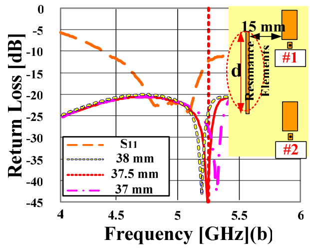


(b) Change of the parasitic elements length.

Fig. 6 Variation of S-parameters according to the number and the length of parasitic elements.



(a) The change of the parasitic elements offset.



(b) The change of the parasitic elements length.

Fig. 7 Variation of S-parameters according to length of parasitic elements.

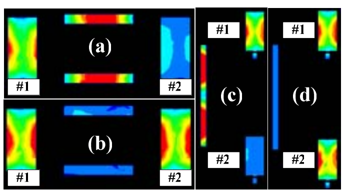


Fig. 8 Current distribution of MIMO antenna.