Mutual Coupling Reduction of Microstrip MIMO Antenna Array by Differential Feeding

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***Abstract*—In this paper, a new method of mutual coupling reduction within microstrip patch MIMO antenna is proposed, based on the theory of differential feeding and a geometry of interlaced subarray. The most remarkable characteristic of this method is that any additional material or structure is not required to insert between the antenna elements. It has been verified by simulation that the mutual coupling of the antenna arrays could be reduced 17 dB through the method of differential feeding compared with that of the coherent feeding.**

Keywords—mutual coupling reduction; differential feeding MIMO; microstrip antenna;

I. Introduction

Mutual coupling is a troublesome problem in multi antenna system, which will reduce the efficiency of the antenna and may have a negative effect on the performance of MIMO system. Thus, how to reduce the coupling between closely spaced antennas has always been a research focus. In recent years, many methods have been proposed to reduce mutual coupling, using the electromagnetic band-gap (EBG) structure, resonator and defected ground structure (DGS). Through the suppression of surface-wave, the coupling between antennas can be deceased by EBGs and the mushroom-like EBG structure is inserted between array elements to reduce the mutual coupling of microstrip antennas [1] and [2]. Different structure resonators are proposed to reduce mutual coupling of antenna array based on the theory of blocking the surface current at the resonant frequency of patch antenna, achieving the purpose of acting as a bandstop resonator that specifically stops the surface current from one unit cell to another unit cell [3]-[5]. In [6], a H-shaped DGS which is able to provide a bandstop effect due to the combination of inductance and capacitance, has been applied to suppress harmonics and cross polarization of a patch antenna, thus to increase the isolation of microstrip patch antenna .

In this paper, an alternative method of mutual coupling reduction between microstrip patch antennas is proposed based on the theory of differential feeding, in which any additional material or structure is not required to insert between the antenna elements. To demonstrate the effectiveness of this method, a dual-port MIMO antenna array is designed working at 16 GHz, each port consists of a dual-element subarray, with the two subarrays interlaced. By comparison of the isolation performance of two MIMO arrays with and without differential feeding, it can clearly illustrates that through the differential feeding network in each subarray and the interlaced geometry, the mutual coupling between the two ports of the MIMO antenna can be greatly reduced.

II. Antenna Design

A. Working principle

The proposed structure is shown in Fig. 1, in which the dual-port MIMO antenna is composed of two subarrays. Each subarray is differentially fed and the two subarrays are interlaced, by such a structure, the induced fields on the middle patch between two adjacent patches are just in opposite phase, thus they will cancel each other out and led to a dramatic decline of mutual coupling. Particularly, there is a 180° phase difference between the feeding current of patch 1 and patch 3, and patch 2 is in the middle of them, thus the mutual coupling produce by patch 1 and patch 3 to patch 2 can be counteracted. The effects of patches 2 and 4 to patch 3 are similar.

To illustrate the effectiveness of this design, a dual-port MIMO antenna with coherent fed subarray is also designed and its S-parameters are analyzed to make a comparison.

B. Antenna structure

As shown in Fig. 1, subarray for port1 is composed of patch 1 and patch 3, which for fort2 is composed of patch 2 and patch 4. Material of dielectric plate is Arlon AD270 whose dielectric constant is 2.7. The height of the plate is 0.5 mm and the other optimized dimension is d_1 = 11.44 mm, d_2 = 3.6 mm, d_3 = 14.12 mm, d_4 = 0.92 mm, L = 7.85 mm, W = 5.23 mm. The other parameters are exactly the same as in Fig. 2.

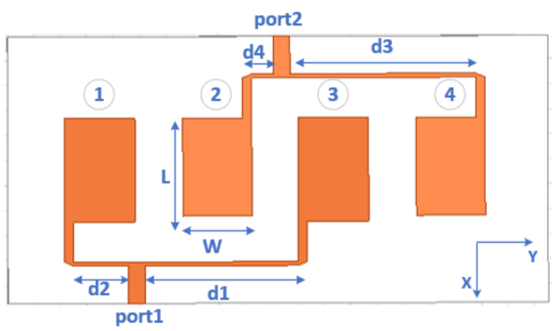


Fig. 1. Antenna array with differential feeding.

The structure of antenna with coherent feeding is shown in Fig. 2. The size is that d = 3.26 mm, d_2 = 1.26 mm, d_3 = 3 mm, d_4 = 3.2 mm, L_0 = 43 mm, W_0 = 20 mm, L_1 = 8.3 mm, W_1 = 5.35 mm, L_2 = 16.3 mm.

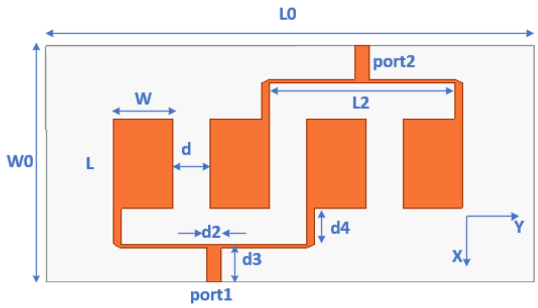
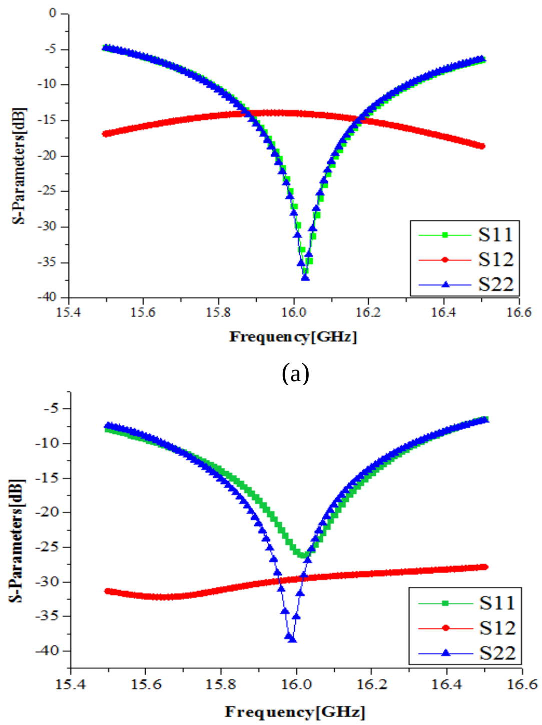


Fig. 2. Antenna array with coherent feeding.

SIMULATION AND DISCUSSION

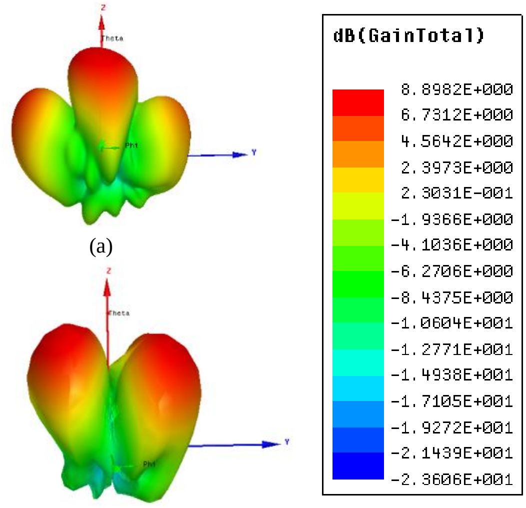
The proposed antennas are designed and optimized by the commercial software high frequency structure simulator (HFSS). Fig. 3(a) and Fig. 3(b) illustrate the simulated scattering parameters of antenna arrays, from which we can see that mutual coupling of the antenna composed of sub arrays with differential feeding is 17 dB lower than that composed of coherent feeding over the frequency band of 15.65-16.30 GHz and the -10 dB impedance bandwidth become bigger compared with that in Fig. 3(b).



(b)

Fig. 3: S-parameters. (a) Antenna with coherent feeding. (b) Antenna with differential feeding.

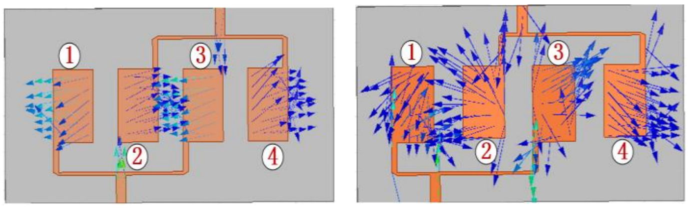
Three-dimensional gains for port1 of the two MIMO antenna arrays are also illustrated in Fig. 4. It is shown that, with differential feeding, two main lobes with gain about 8.89 dBi can be obtained.



(b)

Fig. 4: Three-dimensional gain of the MIMO antenna. (a) Antenna with coherent feeding. (b) Antenna with differential feeding.

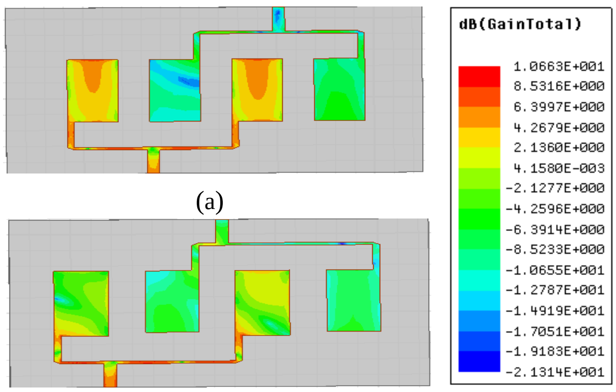
To further illustrate the mechanism of isolation enhancement by differential feeding, the distribution of surface current of the two MIMO antennas is presented in Fig. 5(a) and Fig. 5(b). As is shown in Fig. 5(a), the currents on patch 1 and patch 3 have the same phase, thus their effects on patch 2 are added coherently, on the country, in Fig. 5(b), the currents on patch 1 and patch 3 have opposite directions, thus their induced fields on patch 2 will cancel each other out.



(a) (b)

Fig. 5: The vector form of the surface current distribution. (a) Antenna with coherent feeding. (b) Antenna with differential feeding.

The surface current distribution of antenna array are presented in Fig. 6(a) and Fig. 6(b). It is evident that the surface current of Fig. 6(b) is weaker than Fig. 6(a).



(b)

Fig. 6: The surface current distribution. (a) Antenna with coherent feeding. (b) Antenna with differential feeding.

IIII. CONCLUSION

This paper presents a new method for reducing mutual coupling within the microstrip MIMO antenna array using a differential feeding and a geometry of interlaced subarray. The design model has been analyzed and optimized with HFSS, and it is verified that by differential feeding, the mutual coupling of the antenna arrays could be reduced 17 dB compared with that with coherent feeding.

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