Two Elements MIMO Antenna for a WLAN System

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Abstract— A MIMO antenna with two elements, operating on 2.45-GHz WLAN band frequency, for asymmetric structure MIMO system was designed in this paper. The printed inverted-F and meander line structures were used for the antenna element. Because of the asymmetric structure MIMO system, each of the proposed antennas should be consisted of different dimensions to improve the performance of the MIMO antenna. The isolation, S_{11} and envelop correlation coefficient (ECC) parameters are discussed.

1. INTRODUCTION

Multiple-Input Multiple-Output (MIMO) technology, which utilizes multiple antenna to improve spectrum efficiency and increase the system channel capacity, is one of the key technologies in wireless communication system, such as 4G or WLAN system.

Due to many mounted ICs on the top or bottom PCB of the MIMO system, it is difficult for the simulation of antenna with mounted ICs and we use rectangle as the top and bottom of the PCB for simulation, it is easy to model with this method. The integration of antennas on the MIMO device with very limited space, so there will be mutual coupling between antennas and how to design a MIMO antenna with high isolation is of great importance for MIMO system.

Various printed antennas have been proposed in literature recently. In [1], the proposed antenna consists of two back-to-back planar inverted-F antennas and and a fork-shaped stub for decoupling. In [2], a simple shape of L MIMO antenna with two port for the 2.4-GHz WLAN system is presented. The impedance matching for the WLAN system can easily be achieved by tuning the feeding positions. A proposed dual antenna with a Π-shape grounded strip and covering the entire LTE high band was proposed in [3]. the Π-shape grounded strip not only performs as a radiator but also serves as an isolator to enhance the isolation of the dual-antenna. Three different microstrip MIMO antennas for USB dongle were proposed in [4]. The lumped capacitance and the matching circuit was used for the second designed MIMO antenna system. The usage of a lumped decorrelation capacitance can tune the antenna coupling so that to provide high isolation.

The [5] presented a dual-band IFA-based antenna for a USB dongle application. A branch inserted in the IFA antenna to achieve the higher 5.8 GHz frequency band for the proposed configuration. All the designed antennas in [1–4] have a symmetric structure and may not be suitable for a asymmetric structure system.

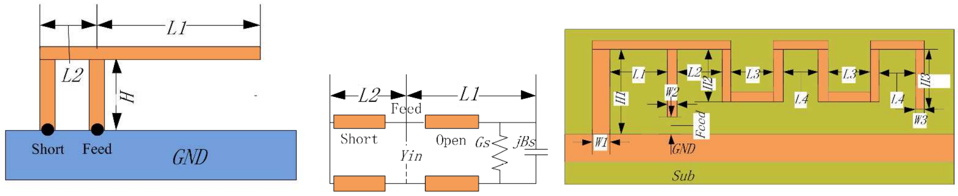
In the present work, a meandered line IFA antenna was used and printed on one top layer of the FR4 substrate with a thickness of 0.8 mm. The antenna was designed to cover the 2.4 GHz WLAN band for a asymmetric structure WLAN MIMO system. It was discussed that the performance of antenna elements with different dimensions which can provide a reference for antenna design of the asymmetric structure MIMO system.

2. ANTENNA DESIGN

The basic antenna element has the shape of English character F, and hence it is called inverted-F antenna. The print IFA is a new different antenna based on the basis of monopole antenna with a short-circuit line, so the transmission line theory of the original model must be modified.

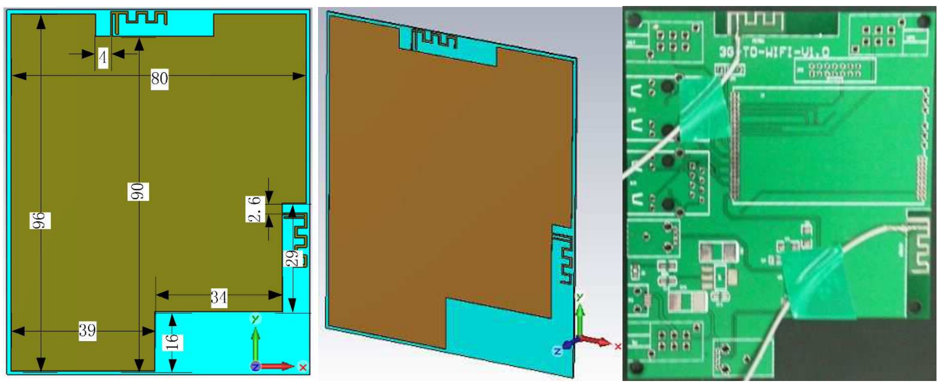
The print IFA can be similar to a transmission line which is shorted in one end and which is opened in another. It can be modeled by the equivalent circuit method and Figure 1 shows the equivalent circuit of printed IFA. According to this model, a formula for evaluating the equivalent admittance of the equivalent circuit is presented as below, Y_1 and Y_2 are equivalent admittance of L_2 and L_1 respectively. Y in is the equivalent shunt admittance of L_2 and L_1.

Where are the characteristic admittance of the micro strip line and the radiation admittance, β is propagation constant. Where Z_0 is the characteristic impedance of transmission line.



(a) (b) (c)

Figure 1: (a) Traditional IFA. (b) The equivalent circuit of IFA. (c) Meandered line IFA.



(a) (b) (c)

Figure 2: (a) MIMO antenna model. (b) MIMO antenna printed on PCB.

Table 1: (mm).

Element	L_1	L_2	L_3	L_4	H_1	H_2	H_3	W_1	W_2	W_3	*Feed*
A	0.8	2	2	2	6	2	2.9	0.5	1	0.6	0.5
B	0.5	2	2	2	6	2	2.9	0.5	0.5	0.6	0.5

In order to reduce the dimension of traditional Inverted-F antenna (IFA) element dimension, the radiation arm with the length of L_1 should be changed. The meandered line instead of straight line of the inverted-F antenna was used for two elements MIMO antenna which shows in Figure 1(c).

The problem of coupling among antenna elements should be solved, because antenna elements are closely spaced in a limited room, and the displacement between antennas have an influence on both space diversity and induced pattern diversity. Many methods for decoupling of MIMO antennas have proposed in recent papers. There are two methods in sum, one is the layout of the antenna elements with different places and the other is the using of special structures between the antenna elements. The former method was selected for our design because of there are no enough spaces adding special structures for the WLAN system. Figure 2 shows the antenna model with dimensions and printed on the top PCB of a WLAN system.

Because of the asymmetric structure of WLAN system, S-parameters of S_{11} and S_{22} will be different. The elements with same dimensions could not have the same S-parameters of S_{11} and S_{22}, hence the design of elements should be consisted of different structures to improve good performance of the MIMO antenna. The dimensions of element A and B are (in millimeters) shown in Table 1.

3. RESULTS AND DISCUSSION

The simulated results are obtained using the software CST. Both S-parameters simulated and measured are showed in Figure 3. As seen in Figure 3(a), comparing with two elements on the same side of the ground pan of WLAN system, the S_{12} parameters is better with two elements on the different side. Figure 3(b) shows simulated S_{11} and S_{22} of the element A and element B using the same dimensions which named TYPE2 (using parameters of element A in Table 1) with different dimensions which named TYPE1 (using parameters of element A and B in Table 1). Comparing with different dimensions of TYPE1, as in TYPE2, the resonance frequency of element A is different from element B and one of the elements' dimensions should be changed to make sure both of resonance frequencies near the 2.45 GHz band for WLAN system.

The 3D farfeild radiationpatterns were simulated by CST. Figure 4 shows simulated patterns of element A and element B at the typical 2.45 GHz frequency. Element 1 is shown in the right and element 2 is shown in the left.

The correlation coefficient (ρ) is a measure that describes how much the communication channels are isolated or correlated with each other. This metric considers the radiation pattern of the antenna system, and how much the patterns affect one another when operated simultaneously. The square of the correlation coefficient is known as the envelop correlation coefficient [6]. The envelop correlation coefficient (ρ_e) can be calculated using the following Formula (1).

$$\rho_e \frac{\left| \iint_{4\pi} \left[\vec{F}_1(\theta,\varphi) * \vec{F}_2(\theta,\varphi) \right] d\Omega \right|^2}{\iint_{4\pi} \left| \vec{F}_1(\theta,\varphi) \right|^2 d\Omega \iint_{4\pi} \left| \vec{F}_2(\theta,\varphi) \right|^2 d\Omega}, \tag{1}$$

where is the three-dimensional field radiation pattern of the antenna when the i port is excited, and Ω is the solid angle. The asterisk is the Hermitian product operator. This is a complicated

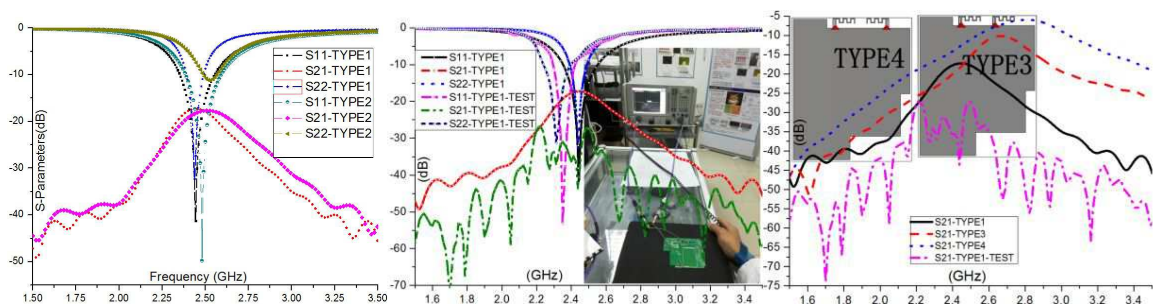


Figure 3: S-parameters.

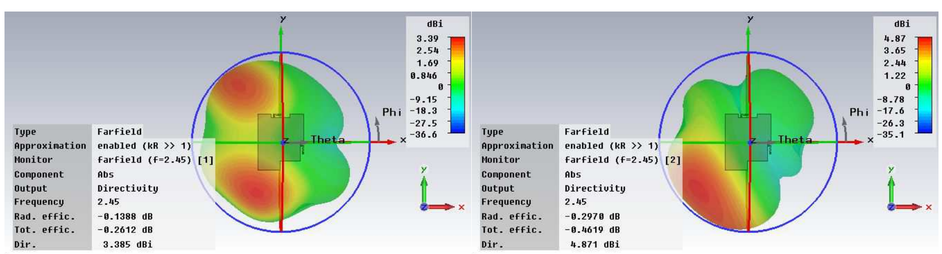
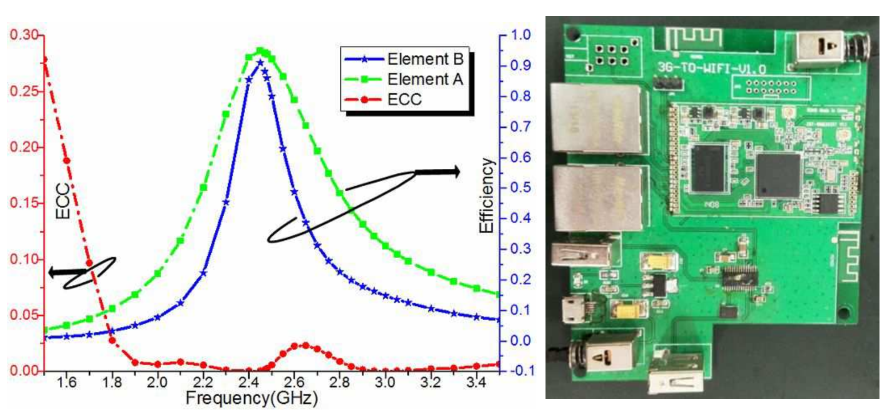


Figure 4: 3D radiation patterns.



(a) (b)

Figure 5: (a) ECC and element radiation efficiency. (b) WLAN system.

expression that requires three-dimensional radiation-pattern measurements and numerical integration.

As shown in Figure 5(a), the radiation-pattern-based ECC of the proposed MIMO antenna has the ECC of below 0.03 near 2.45-GHz frequency bands. The total efficiencies of element A and element B were shown in Figure 5(b) and both element A and B have a efficiency more than 80% at the 2.45 GHz band. Two elements meander line inverted-F antenna with different sizes integrated in the WLAN MIMO system were shown in Figure 5(b).

4. CONCLUSION

The MIMO antenna with two elements for WLAN system at the 2.45-GHz band has been simulated and test in this paper. The antenna element was of meandered line printed inverted-F structure. The antenna elements were printed on the top PCB of a WLAN system. To compare with the simulated and test results, the test resonance frequency have a shift to the lower band than simulated and the test S_{21} was better than simulated. Too many mounted ICs on the top or bottom PCB of the MIMO system might yield the different results and authors should have a consider during the process of simulation. It also can be used at 5.8-GHz band WLAN system if the dimensions of antenna elements were reduced. Unlike the conventional MIMO antennas with a symmetrical structure, this antenna verified that elements dimensions should be different to get a same working bandin the practical MIMO system.

ACKNOWLEDGMENT

This work was supported by Guangdong Peizheng College Key Research Program (Nos. 14pzxmyb0 13 and 14pzxmzd02), the partial support of Guangdong Innovative Research Team Program (No. 201001D0104799318), the National High Technology Research and Development Program (863 Program) of China (No. 2012AA030402) and the National Natural Science Foundation of China (No. 61108022).

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