A High Isolation MIMO Antenna Used a Fractal EBG Structure

Haiming Wang, Dongya Shen, Teng Guo，Xiupu Zhang
School of Information Science and Engineering
Yunnan University, Kunming, China
shendy@ynu.edu.cn, 441ming@163.com
guoteng208@gmail.com, xzhang@ece.concordia.ca

Abstract- **To further reduce the coupling of a MIMO antenna containing a mushroom-like EBG structure, we propose a novel MIMO antenna by using a fractal mushroom-like EBG structure to realize a high isolation. The simulated band width of the antenna is 2100 to 2830 MHz (S11＜-10 dB), covering the bands of WLAN and WiMax. Compared to the antenna of using mushroom-like EBG structure, the antenna proposed in the paper has higher isolation and smaller dimension.**

Key words: **- MIMO; Antenna; Fractal; EBG; WLAN; Wimax**

I. Introduction

The coupling between closely placed antenna elements is an important factor to the antenna performance, especially to the antenna used for the multiple-input-multiple-output (MIMO) wireless communication systems.

It is difficult to get high isolation between closely spaced antenna elements. Many researches have been studied. One solution reported often consisted in moving the antennas with different orientations around the printed circuit board (PCB) [1-3]. The best isolation values are always found when the antennas are spaced by the largest available distance on the PCB.

Other methods for improving the isolation have been reported. In [4], J. OuYang et al presents a slot structure perpendicular to current on the surface of patches to improve the isolation of a pair of closely spaced microstrip antennas on a common ground plane. Besides, a protruding T-shaped stub in the ground plane was used to improve the mutual coupling between antenna elements [5], [6]. Similarly, a T-shaped and dual-inverted-L-shaped ground branch was added to acquire low mutual coupling [7]–[11]. Unfortunately, the high isolation covering the wide band is difficult to realize.

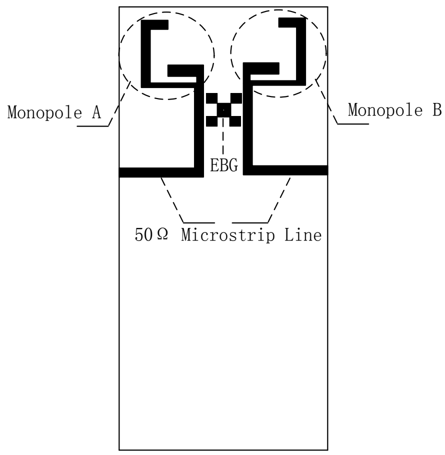
In recent years, the electromagnetic band-gap (EBG) is applied to mitigate mutual coupling between the antennas. Most antennas designed mainly utilize the EBG matrix, offering an efficient means to reduce antenna coupling [12-14]. However, the proposed design occupied a large space between the antennas. In [15], the authors utilize a single lattice mushroom-like EBG between the antennas to reduce the coupling preferably and the size of the antenna.

In this paper, a fractal EBG structure is proposed to improve the Isolation of the MIMO antenna proposed in [15]. Except for the EBG structure, the antenna structure is similar to one in [15], which is based on a G-shaped monopole antenna structure with two back-to-back monopoles. The fractal EBG structure, instead of the lattice mushroom-like EBG is used in the new antenna to increase the isolation of the antenna. Also, several ground branches are introduced to increase the isolation or adjust the resonant frequency. Compared with the antenna in [15], the new MIMO antenna has better performances, higher isolation and the smaller size. The isolation for frequencies across 2100 to 2830 MHz(S11＜-10 dB) increased 2dB to 21dB, and the size of the antenna decreases for the smaller EBG used in the antenna. The MIMO antenna designed in this paper can be used to WLAN and WiMax.

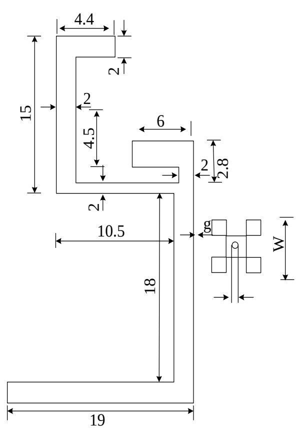
II. ANTENNA CONFIGURATION

The geometry of the proposed fractal EBG antenna is demonstrated in Figure 1(a). Figure 1(b) and 1(c) show the front side and back side of the antenna respectively, also labelling all the dimensions in detail. The new antenna is printed on an FR4 substrate with dimensions 99 mm×54 mm ×1.6 mm and relative permittivity of 4.4, which can be considered as the circuit board of a mobile handset. The ground with main sizes 80mm×54mm and two inverted L-shaped branches are printed on the back surface of the substrate. Two monopoles adopting folded techniques are designed to reduce the occupied area. Two symmetric back-to-back G-shaped patches, only 16 mm in height, are printed on the front side of the substrate. For convenience of design, the width of all antenna braches is set to be 2 mm in this paper except for the bottom branch of the G-shaped antenna, which has a width of 1.2 mm. The dual inverted L shaped ground is introduced in this design to obtain wide bandwidth. The detailed function analysis of the ground can be found in [8-11]. The lengths from the feeding point to the end of the metal are smaller than one-quarter wavelength of a conventional straight monopole in free space. This behaviour is largely due to the effect of the microwave substrate supporting the proposed monopole, which leads to decrease resonant length for the proposed monopole. This effect is also helpful for achieving a smaller antenna size for a fixed operating frequency.

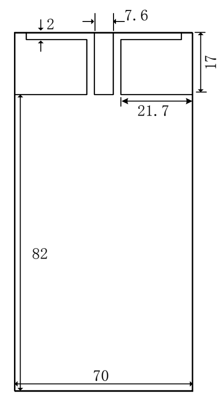
Each monopole is directly fed using a 50Ω microstrip line printed on the front surface of the substrate. A Good impedance matching is obtained without adding additional matching circuitry. Between the two monopoles, there is a T-shaped ground plane protruding from the main plane (60×80 mm2). The protruded and main ground planes are both printed on the back surface of the substrate, and the inverted L-shaped ground plane comprises a central vertical strip and a top horizontal strip, both with a constant width of 4 mm. Note that the inverted L-shaped ground plane enhances the isolation between the two ports of the antenna.



(a)



(b)



(c)

Fig. 1. Geometry of the proposed diversity antenna (a) General view, (b) Dimensions of monopole & EBG structure, and (c) Dimensions of the ground plane.

The EBG, called as fractal EBG, formed by a via-loaded metal patch and a Minkowski fractal dimension, is inserted between two microstrip feed lines of antenna. It can be regarded as an LC resonator with resonant frequency $f_r = 1/2\pi\sqrt{LC}$ .When a single cell is used, a narrow notch at f_r can be engendered.

III. EFFECTS OF THE GEOMETRICAL PARAMETERS OF THE PROPOSED ANTENNA

A. *Effects of the Parameter W*

The simulated return losses with changing W= 5mm, 5.5mm, 6mm, 6.5mm, 7mm are shown in Figure 2. It is revealed that the parameter W has more effects on the resonant frequency. Within the bandwidth (S11＜-10 dB), there is a notch corresponding to the arch in Figure 2. With the increasing of the parameter W, the value of S11 in the notch decreases, but bandwidth is not significantly changed. When W=6 mm, its return loss close to -22 dB, and the bandwidth keeps the performance all right.

Figure 3 gives the simulated results of the isolation between Port 1 and 2 with changing W= 5mm, 5.5mm, 6mm, 6.5mm, 7mm Within the bandwidth (S11＜-10 dB), with the increasing of the parameter W, the values of S21 is same basically. Considering the S11 and S12 synthetically, the optimal dimension W is chosen as 6mm.

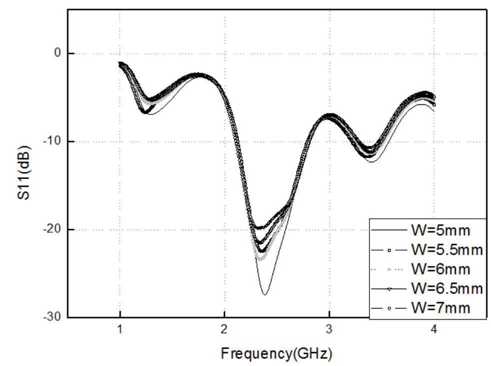


Fig.2. The return loss with different W

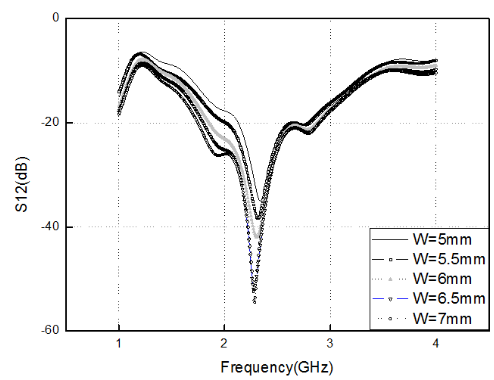


Fig. 3. The isolation between ports with different W

B. *Effects of the Parameter g*

The simulated return losses and isolation with changing g=0 mm ,0.1 mm ,0.2 mm ,0.3 mm ,0.4 mm are shown in Figure 4 and Figure 5 respectively. It is observed from the two figures, with the increasing of g, the values of the return losses and isolation improved well. Considering the S11, S21 and the size of the antenna synthetically, the optimal dimension g is chosen as 0.3 mm.

IV. RADIATION PATTERNS ANALYSE

The simulated radiation patterns of Port 1 and Port 2 excited at 2470GHz and 2700MHz are given in Figure 6 and Figure 7 respectively. Comparing Figure 6 and Figure 7, one can find that the patterns tend to cover complementary patterns, which provide pattern diversity for the system operation. All these demonstrate that the antenna can overcome the multipath fading problem and enhance the system's performance.

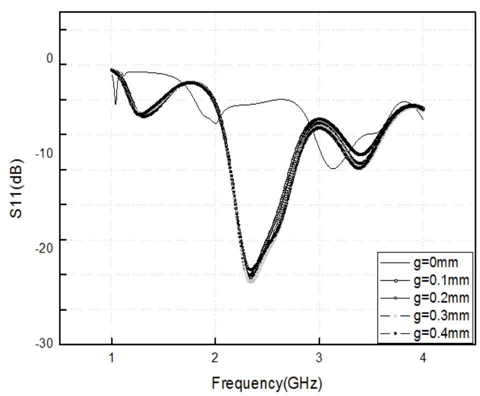


Fig.4. The isolation between ports with different g

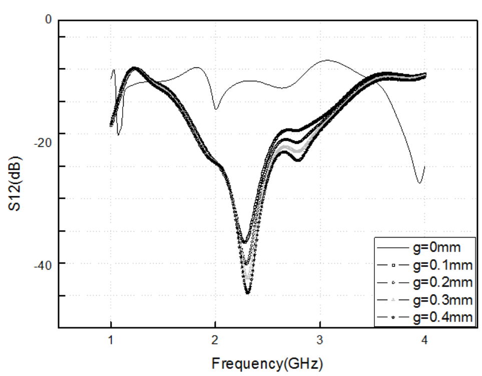
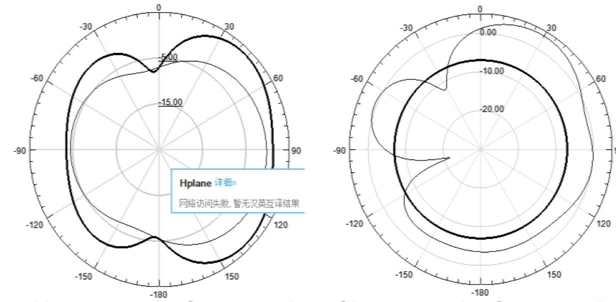


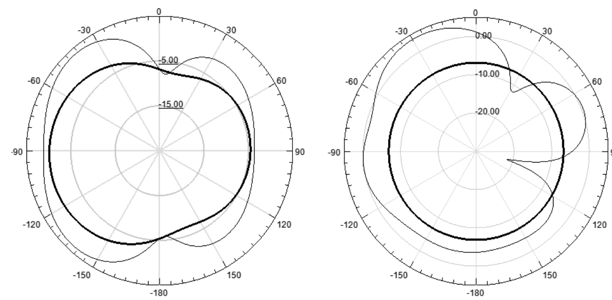
Fig. 5. The isolation between ports with different g

V. THE COMPARISON AND ANALYSIS OF THE ANTENNA PERFORMANCE WITH DIFFERENT EBG STRUCTURE

The comparison is performed between a Minkowski fractal EBG structure antenna (as shown in Figure 1a) and a square (mushroom-like) EBG structure one (as shown in Figure 8 in [15]). The simulated return losses and isolation at the optimal W and g=0.3mm are shown in Figure 9a and 9b, respectively. It can be found that the return losses of both are same at W=6mm of fractal EBG structure antenna and at W=7mm of square EBG antenna, while the isolation with fractal EBG (S12＜-21dB) is better than that with the square one(S12＜-19dB).

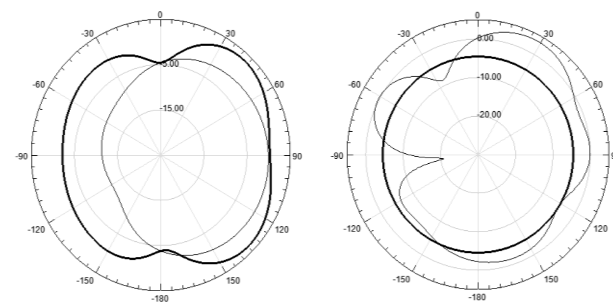


(a) 2470MHz (E-plane, port 1) (b) 2470MHz (H-plane, port 1)

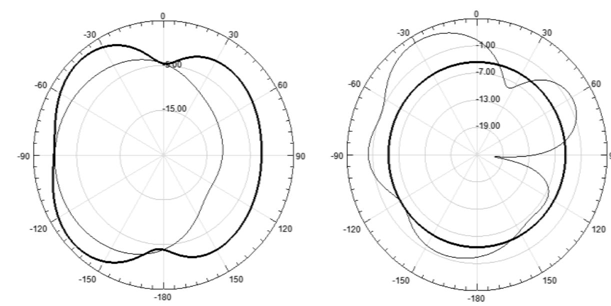


(c) 2470MHz (E-plane, port 2) (d) 2470MHz (H-plane, port 2)

Fig.6 Simulated Radiation patterns at 2470MHz



(a)2700MHz (E-plane, port 1) (b)2700MHz (H-plane, port 1)



(c)2700MHz (E-plane, port 2) (d)2700MHz (H-plane, port 2)

Fig.7 Simulated Radiation patterns at 2700MHz

VI. CONCLUSION

A novel high isolation MIMO antenna has been proposed and studied in this paper. On the basis of simulated results, the optimal values of the parameters are chosen and the radiation mechanisms are studied. The final simulated bandwidth (S11) is 2100 to 2830MHz with high isolation(S12＜-21dB) for frequencies across the WLAN and WiMax bands, the size of the antenna has also been decreased effectively. Compared with similar antennas, the proposed antenna can provide higher isolation and smaller dimension in real applications.

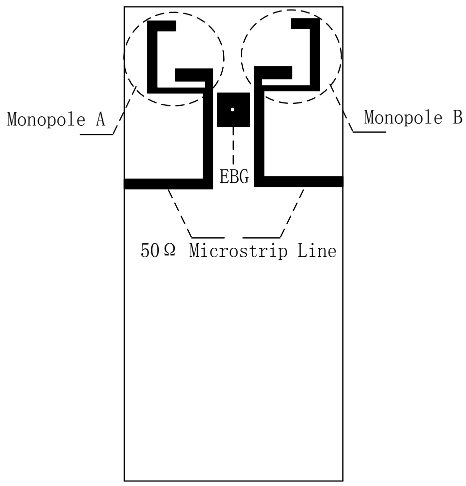
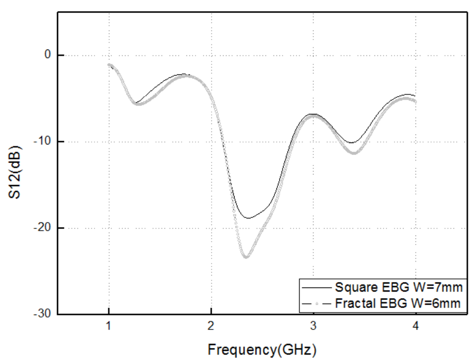
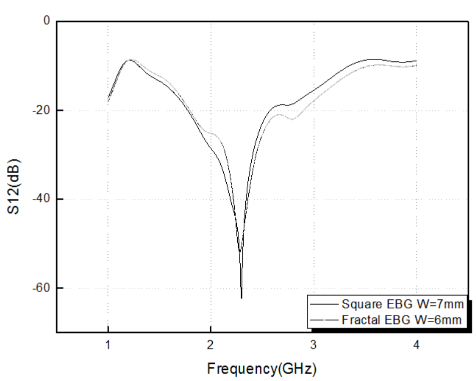


Fig.8. Geometry of square (mushroom-like) EBG structure antenna



(a) The return loss



（b）The isolation

Fig. 9 The comparison of the simulated return losses and isolation of both antennas

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