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A NOVEL DUAL-POLARIZED ANTENNA WITH HIGH ISOLATION AND LOW CROSS POLARIZATION FOR WIRELESS COMMUNICATION

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Abstract—In this paper, a new design of a dual-polarized antenna with high isolation and low cross polarization is proposed. The main radiation structures comprise two pairs of petaloid patches, which are fed by coaxial lines. Behind the patches, a U-shaped ground is placed to improve the front-to-back ratio of the antenna. Stable and symmetric radiation patterns at slanted $\pm 45^\circ$ polarization have been obtained within the frequency band 1.71–2.17 GHz. A return loss of -14 dB is achieved and measured isolation between the two input ports is over 31 dB. The 3 dB beamwidths of the two polarizations is stable (65°) and the average gain of the proposed antenna is about 9 dBi across the whole frequency band.

1. INTRODUCTION

In order to improve communications capacity and quality, many techniques are developed and applied. One of the most commonly used techniques is polarization diversity. This means the antenna of the system should have dual polarization [1–6]. For antenna engineers, obtaining high isolation and low cross polarization is a great challenge and many efforts have been taken. Several dual-polarized antennas have been suggested in the past fifteen years [7–10]. These antennas with aperture-coupled have many advantages, such as eliminating the soldering process and limiting interfering with radiation from the radiation patches to the feed network. But the slot radiates both in the patch direction and in the back direction, which results in low gain and low front-to-back ratio. Two methods proposed in [11] can minimize the back-radiation of the dual-polarized patch antennas but involving

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several layers which gives rise to complexity in antenna fabrication. Another way to get low cross-polar levels is using two hybrid input ports [12] which results in a complex structure.

In this paper, a broadband dual-polarized element composed of four petaloid patches inside a rectangular metal fence and a U-shaped ground behind the radiation element are presented to constitute the antenna. The antenna produces a low cross-polar level. Measured results show improvement in isolation between the polarization ports while maintaining a broad impedance bandwidth covering existing DCS, PCS and 3G mobile communication systems operating at 1.71–2.17 GHz. The 3 dB beamwidths of the two polarizations vary only several degrees over the frequency band. By contrast with aperture coupled antennas, this proposed antenna has the advantages of simple structure and low cost.

2. ANTENNA DESIGN

The basic configuration of the proposed antenna is illustrated in Fig. 1. Two pairs of petaloid patches are printed on the FR4 substrate with a thickness of 0.8 mm. Each pair of patches is considered as an electric dipole feeding by a coaxial probe through the air bridge. In an attempt to restrain the cross polarization generated by the petaloid patches, the squared metal fence with a side length of L_1 is introduced and printed on the same substrate with the radiation patches. Four parts are dug inside the square patch in order to contain the petaloid patches. Thus, all patches are printed on a single layer. The positions of feeds are symmetrical at the patches shown in Fig. 1. There is a small gap with a length of 0.7 mm between the adjacent patches. The U-shaped ground is utilized to generate the required front-to-back ratio for cell sector design. The radiation patches are separated from the ground with a height of 38 mm which is $\lambda/4$ at the center frequency

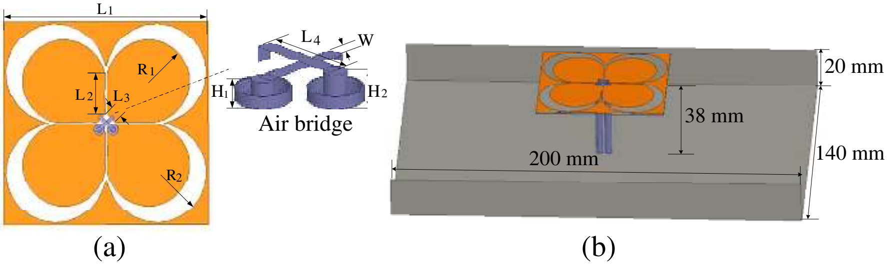


Figure 1. Geometry of proposed antenna element.

1.94 GHz. Fig. 2 presents the photo of the fabricated antenna. The whole structure was modeled using commercial software Ansoft HFSS with the following parameter details, $L_1 = 62$ mm, $L_2 = 13.9$ mm, $L_3 = 3.6$ mm, $L_4 = 6$ mm, $w = 1$ mm, $R_1 = 12.6$ mm, $R_2 = 14$ mm, $H_1 = 1.3$ mm, $H_2 = 1.8$ mm.

3. RESULTS

The measured return loss and the isolation of the dual-polarized antenna are shown in Fig. 3. It is observed that a bandwidth of 23.7% is achieved when maintaining the return loss below −14 dB for both ports, which fulfils the required operating frequency band from 1.71 to 2.17 GHz and can cover the DCS, PCS and 3G frequency bands adequately. The measured $|S_{12}|$ between the two input ports of the dual-polarized antenna is lower than −31 dB over the whole frequency band.

In this designation, although the closed metal fence is introduced

Figure 2. Photo of the fabricated antenna element.

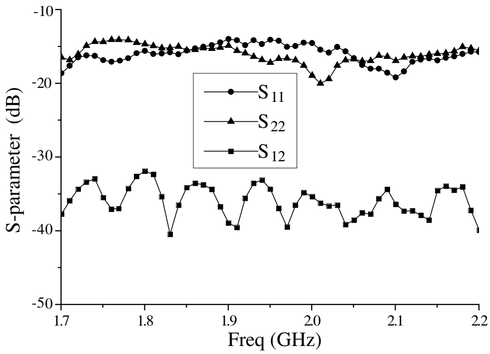


Figure 3. Measured return loss and isolation.

mainly to restrain the cross polarization, the size of the dug parts also has effects on $|S_{11}|$ of the antenna. The simulated cross-polar of the antenna with varying R_2 are shown in Table 1. It can be seen that the cross polarization has been greatly improved by adding the fence, and the increase of R_2 results in a slight reduction of the cross-polar. Fig. 4 shows the impact of fence on the return loss with all parameter dimensions fixed except for R_2. It is observed that a better S_{11} can be obtained with the increase of R_2. In addition, the rectangle patch should be closed, so the radius R_2 is selected to be 14 mm as a tradeoff in the paper.

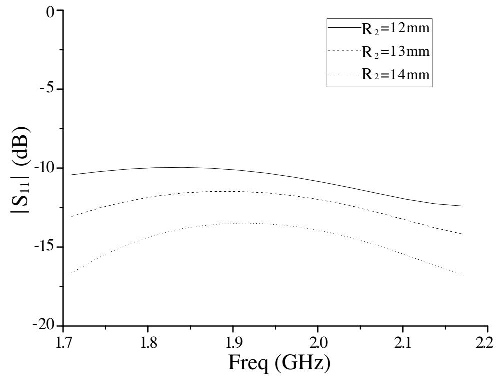
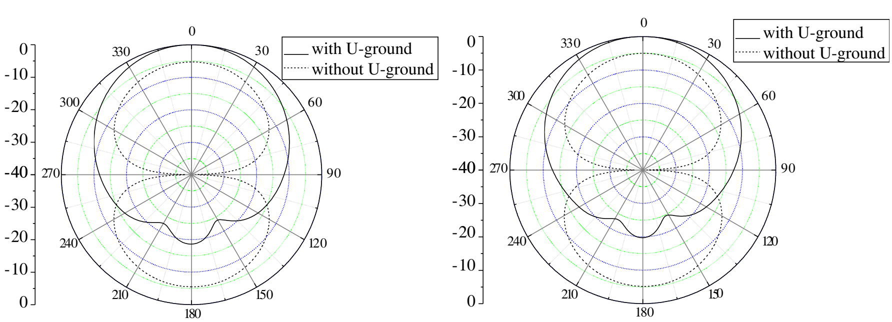


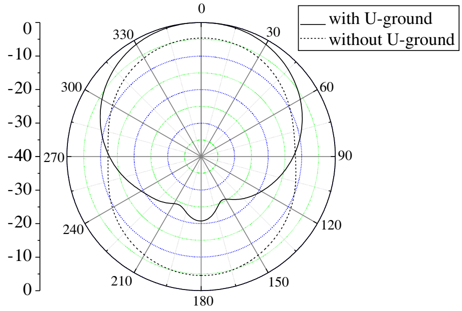
Figure 4. Simulated return loss with various R_2.

Table 1.

Freq (GHz)		Cross-polar (dB)			
		Without metal fence	$R_2 = 12\,\text{mm}$	$R_2 = 13\,\text{mm}$	$R_2 = 14\,\text{mm}$
$+45°/-45°$	1.71	19.9/20.3	24.4/25.1	24.3/24.9	24.6/24.5
	1.94	22/22	25.7/26	25.8/25.9	25.3/25.5
	2.17	23.1/22.6	30/30	29.9/28.8	28.1/28.5



(a) (b)



(c)

Figure 5. Effect of the U-shaped ground on the front-to-back ratio. (a) 1.71 GHz. (b) 1.94 GHz. (c) 2.17 GHz.

Table 2.

Frequency (GHz)		3 dB beamwidth (deg)	Cross-polar (dB)	Front-to-back ratio (dB)	Element gain (dBi)
+45°/−45°	1.71	67/67	23.7/23.0	21.1/20.8	9.0/8.9
	1.94	65/65	25.6/25.2	22.3/22.1	9.1/9.1
	2.17	62/62	27.4/27.2	23.1/22.2	9.2/9.2

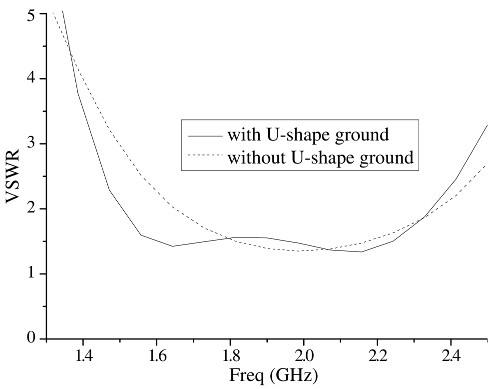


Figure 6. Simulated VSWR with and without U-shaped ground.

The comparison of simulated E-plane radiation patterns between antenna with and without U-shaped ground is shown in Fig. 5. It is observed that the U-shaped ground has a remarkable effect on the reduction of the back radiation. The patch antenna without reflector radiates the same in front and back direction. After adding the U-shaped ground, 20 dB front-to-back ratio can be obtained.

Simultaneously, the gain increases about 6 dBi with the introduction of the ground. Fig. 6 shows effects of the U-shaped ground on VSWR, which indicates that the VSWR changes a little in the whole operating band except that low resonance frequency becomes lower. Because of the geometric symmetric and good isolation of the two polarizations, the VSWR properties of the two input port are similar, so only one is analyzed here.

The measured radiation patterns of the antenna, at the operating frequencies 1.71, 1.94 and 2.17 GHz, are plotted in Fig. 7 and Fig. 8. The figures show that the radiation patterns at both slanted +45° and −45° polarization are very similar and symmetrical to each other. Detailed measured parameters such as the half-power beamwidth, gain and front-to-back ratio of the proposed antenna are provided in Table 2. The cross polarization is low and the 3 dB beamwidths of the two polarizations vary only several degrees over the frequency band. Very stable radiation patterns across the pass band are achieved. The front-to-back ratio of the dual-polarized antenna is over 20 dB, and the gain is stable at about 9 dBi.

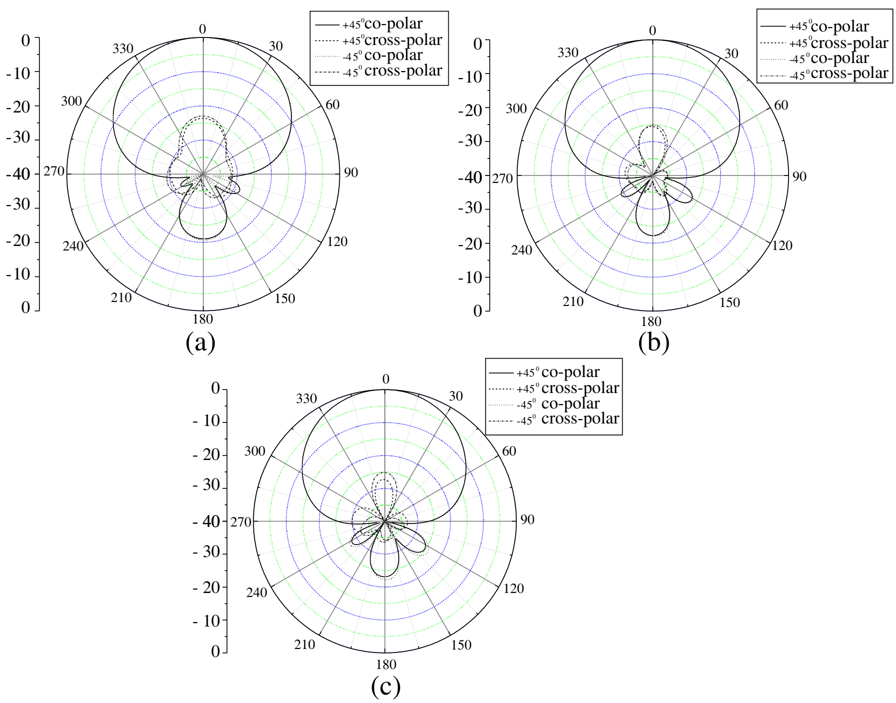


Figure 7. Measured E-plane radiation pattern for ±45° polarization. (a) 1.71 GHz. (b) 1.94 GHz. (c) 2.17 GHz.

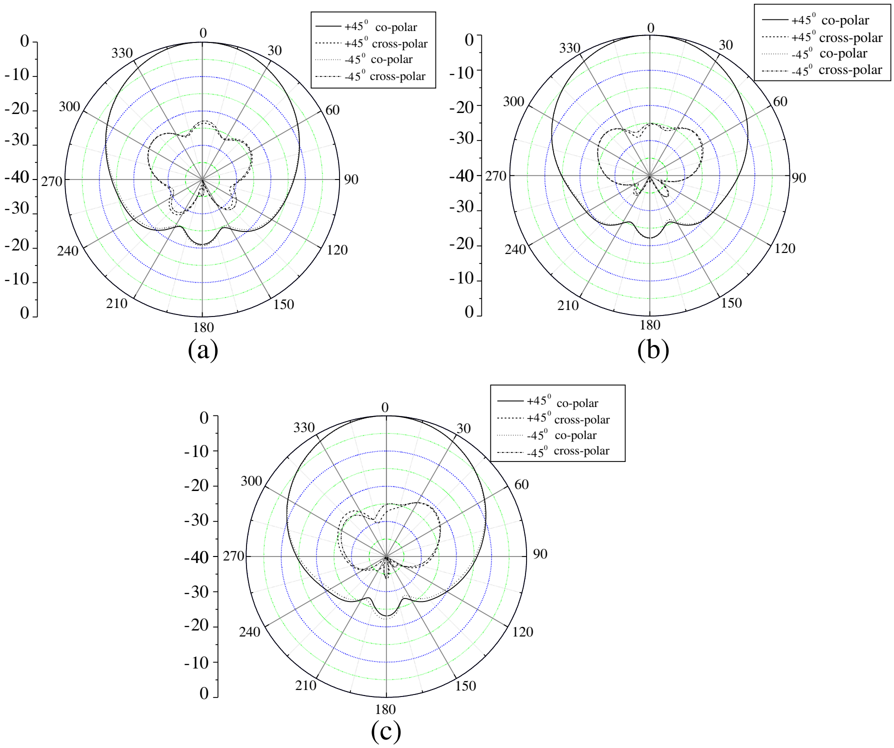


Figure 8. Measured H-plane radiation pattern for $\pm 45^\circ$ polarization. (a) 1.71 GHz. (b) 1.94 GHz. (c) 2.17 GHz.

4. CONCLUSIONS

A new dual-polarized antenna has been designed and tested. The dual polarization with high isolation level better than 31 dB can satisfy nowadays wireless communication criterion. The broadband antenna has low cross polarization, symmetrical radiation patterns and is easy to fabricate. It can also retain a stable 3 dB beamwidths of the two polarizations over a wide frequency band between 1.71 G and 2.17 GHz.

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