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COMPACT AND WIDEBAND DUAL-POLARIZED ANTENNA WITH HIGH ISOLATION FOR WIRELESS COMMUNICATION

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Abstract—A wideband dual-polarized antenna with high isolation is presented. Four printed quadrant planar folded dipole placed above a U-shaped reflector are adopted as the main radiation elements. Curved slots cut on the planar folded dipole are used to reduce the size of the antenna. Parameter is studied, and the values are adjusted in order to obtain wideband and compact properties. Measured results show that the antenna achieves a VSWR < 2.0 from 1.64–2.33 GHz. The isolation between the two polarizations is better than 29.5 dB. The radius of the quadrant planar folded dipole is only 34 mm (about 0.18 wavelength at 1.64 GHz).

1. INTRODUCTION

Dual-polarized wideband antenna is widely needed in wireless communication systems that need polarization diversity. For this application, the critical requirements include compact size, wide bandwidth, high isolation, low cost, etc. Microstrip antenna is the usual choice for compactness antenna design, but the isolation performance of traditional microstrip antenna may not be good enough. The techniques of aperture coupled feed [1, 2] and "dual feed" [3, 4] can be used to improve the isolation properties, but they will increase the height or complexity of the antenna. There are also

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many good designs for the dual polarized antennas [7–16]. All the antennas achieve wide bandwidth and high isolation performances. We also presented a broadband dual-polarized antenna with two end-to-end dipoles, and a similar improved antenna was proposed. The two dipoles are cross-placed for orthogonal polarizations in this design with the ends connected with each other to improve the isolation. Both of the antennas show good bandwidth, isolation and cross-polarization performances. However, the size of each of the antennas is not very compact.

In this paper, a wideband dual-polarized antenna composed of two pairs of printed quadrant planar folded dipoles with slot cuts is proposed. Unlike the antennas mentioned above, circular shape is used here, which will reduce the size of the antenna. The slot cuts are also beneficial to the size reduction. The compact property of the antenna is achieved after all the efforts. The compact property is very useful in some applications, especially when the antenna is interlaced with the antenna for lower frequency. The antenna operates from 1.64–2.33 GHz with VSWR < 2.0, which can cover all the existing DCS, PCS and 3G mobile communication systems bands. The measured results show that good isolation which is more than 29.5 dB over the whole working band. The pattern performances of this antenna are also good. Details of the antenna design and both theoretical and experimental results are presented and discussed.

The paper is organized as follows. Section 1 is the introduction. Section 2 is description of the antenna design and geometry. The simulated and measured results of this antenna are presented in Section 3 including some discussions on the key design parameters of this antenna, and the conclusion is given in Section 4.

2. ANTENNA DESIGN AND DESCRIPTION

The configuration of the proposed wideband dual-polarized antenna element with good isolation is shown in Fig. 1. Four quadrant planar folded dipole are printed on a 0.8 mm thick Arlon AR 450 substrate. The four folded dipoles can be divided to two pairs, and each pair consists of two folded dipoles which are symmetrical with each other. The two pairs of folded dipoles are for two orthogonal polarizations. The two folded dipoles in one pair are connected with printed parallel feeding lines and fed at the center of the antenna. The antenna is fed by cables, whose outer part is connected to one of the parallel feeding line arms and inner part to the other arm of the feeding line. At the end of the folded dipole, there is a triangular cut used to match the antenna to 50 Ω well. There are two ports for this antenna. Port 1 is

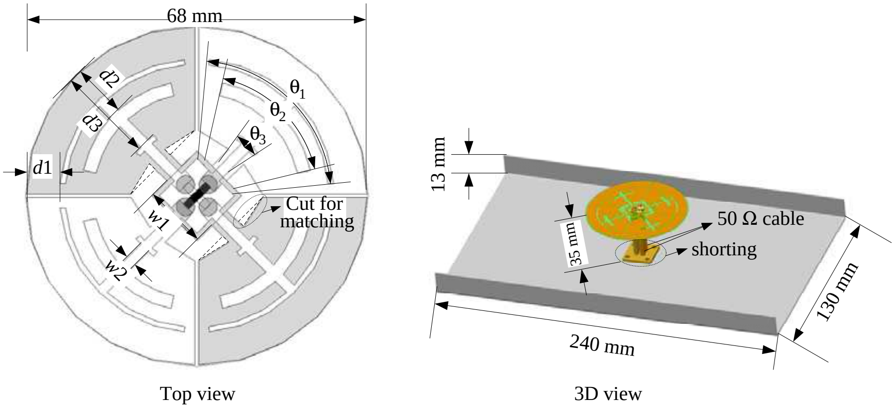

Figure 1. Geometry of proposed antenna.

for +45° polarization and port 2 for −45° polarization.

The antenna is placed above a U-shaped reflector ground with a length of 240 mm, width of 130 mm and height of 13 mm, which is to obtain directional radiation patterns and controls the pattern beam width. The outer part of the cable is also connected to the ground, which will connect one arm of the feeding line to the ground. There is another metal post at the symmetrical place with the cable connecting the other arm of the feeding line to the ground. The outer part of the cable and the shorting metal post will produce a balun, which make the feed of the antenna good. One thing should be mentioned: the U-shaped reflector ground size affects the antenna performance little. Only when the width changes from 100 mm to 180 mm, the realized gain of the antenna will change about 0.5 dB.

3. RESULTS AND DISCUSSIONS

To analyze impedance and pattern, the proposed antenna was first simulated by the EM full-wave simulator HFSS. An antenna prototype is also fabricated for verification. The operation frequency range is mainly determined by adjusting D (the diameter of the antenna). The lowest frequency $F_{\min}$ is roughly evaluated:

$$F_{\min} = \frac{300}{(0.5\pi + 1.0)D} \text{ (GHz)}$$

The optimized parameters of the antenna in accordance with the configuration in Fig. 1 are given in Table 1. The antenna photograph is shown in Fig. 2.

Figure 2. Photograph of proposed antenna.

Table 1. Dimensions of proposed antenna.

Symbol	**Size**	**Symbol**	**Size**
$d1$	6.6 mm	θ_1	81 deg
$d2$	10.8 mm	θ_2	66 deg
$d3$	19.2 mm	θ_3	20 deg
$w1$	12.6 mm	$w2$	2.1 mm

The antenna prototype is also measured using Agilent E8362B vector network analyzer. The simulated and measured VSWRs and isolation results of the proposed antenna are shown in Fig. 3. The results show that the antenna can cover a frequency band from 1.64 to 2.33 GHz with $S_{11} < -10$ dB. The isolation between the two input ports of the dual-polarized antenna is better than 29.5 dB over the entire bandwidth. The measured and simulated results are relatively agreeable and the disagreement may be caused by fabrication error.

The measured normalized radiation patterns of the antenna, at frequencies of 1.7 GHz, 1.95 GHz and 2.2 GHz, are plotted in Fig. 4. The figure shows that the radiation patterns at both $+45°$ and $-45°$ polarization are very similar and symmetrical to each other. Detailed parameters including the half-power beam width, gain and front-to-back ratio of the proposed antenna are provided in Table 2. The cross polarization is the highest cross polarization value in the -3 dB beam, and the front-to-back ratio is the ratio of the radiation value in the broadside and the highest radiation value in the beam of $180 \pm 20°$.

In order to explain the working mechanism of this antenna, the current distributions on the main radiation element when port 2 is excited are plotted in Fig. 5. It can be seen that the current concentrates along the slots on the most outside circle, which shows that the main radiation elements are the folded dipoles.

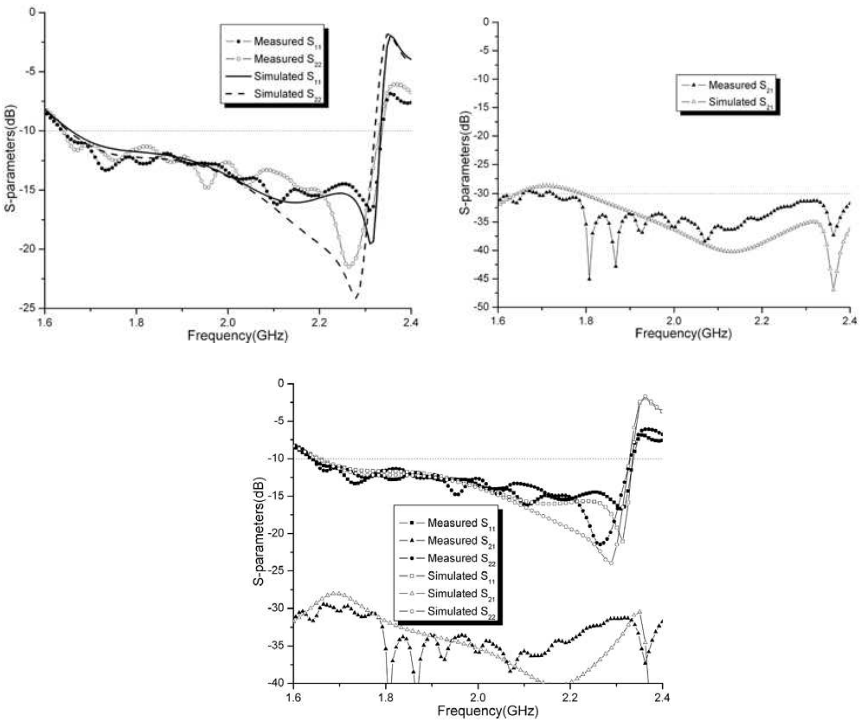

Figure 3. Simulated and measured S-parameters.

In the study of the performance of this antenna, the effects of the parameters θ_1, θ_2 and $d1$ as shown in Fig. 1 are found to be the most apparent. The effect of varying the three main parameters is studied via simulations. In all cases, other parameters are held constant while one is varied. Fig. 6 depicts the effect of varying the θ_1 on the reflection coefficient. It is seen that the working frequency band of the antenna moves higher as θ_1 decreases, but the first resonant frequency moves more apparently than the second one.

The effect of θ_2 on the reflection coefficient is shown in Fig. 7. It is seen that this parameter mainly affects the second resonant frequency which will shift to higher part as θ_2 decreases. The variation of θ_2 does not affect the first resonant frequency.

In Fig. 8, the effect of parameter $d1$ is presented. It is noted that the first resonant frequency of the antenna becomes lower as $d1$ decreases, thereby increasing the bandwidth, but at the expense of higher reflection coefficient in the mid band. By judiciously selecting $d1$, a compromise between good reflection coefficient and bandwidth is obtained.

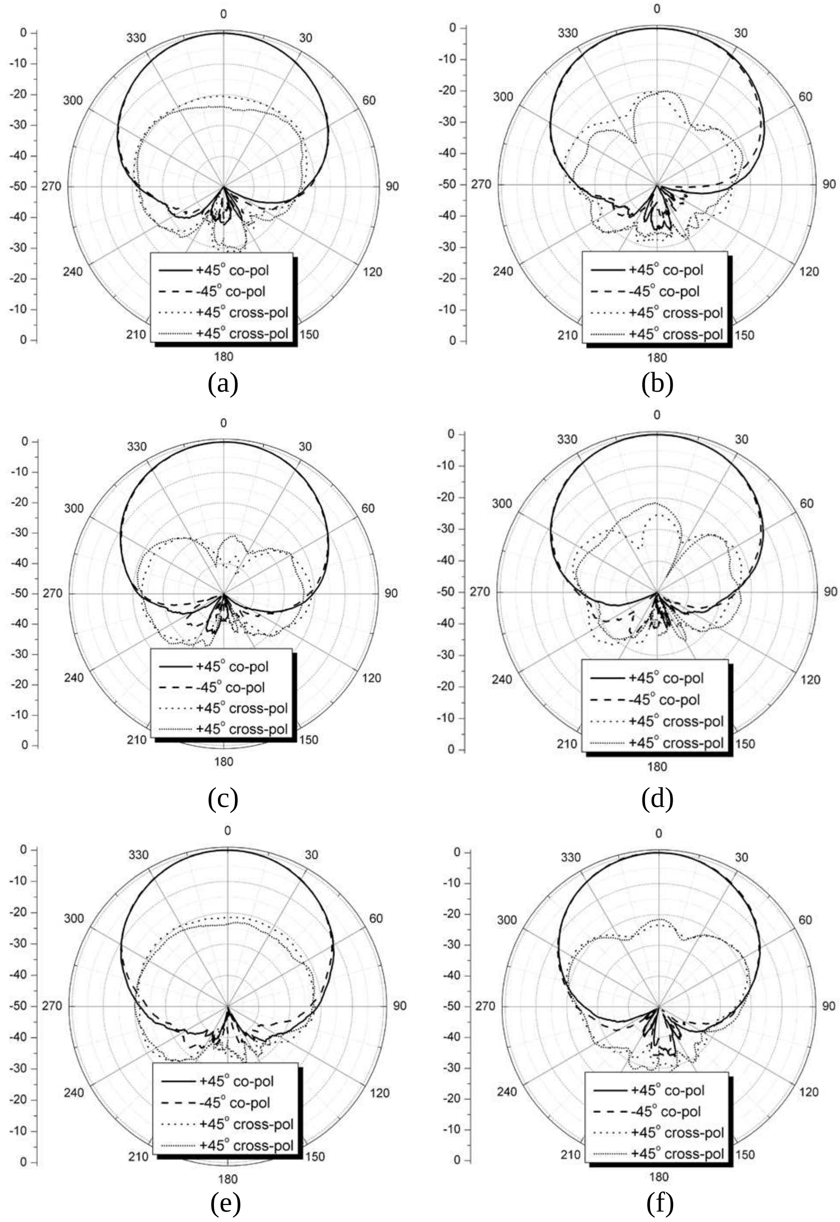

Figure 4. Measured radiation patterns of proposed antenna. (a) 1.7 GHz, azimuth plane. (b) 1.7 GHz, elevation plane. (c) 1.95 GHz, azimuth plane. (d) 1.95 GHz, elevation plane. (e) 2.2 GHz, azimuth plane. (f) 2.2 GHz, elevation plane.

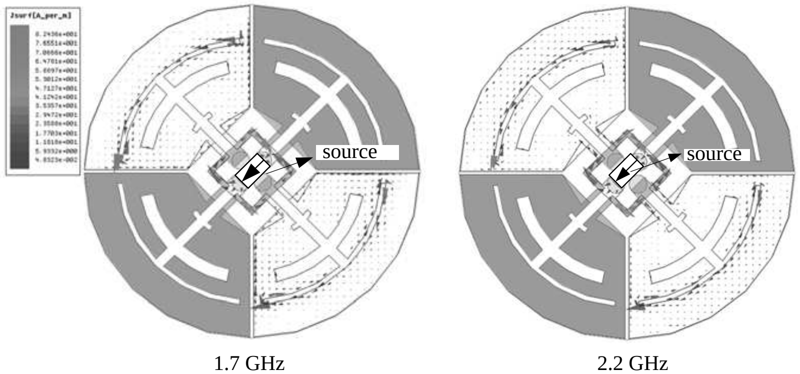

Figure 5. The simulated current distribution on the surface of the antenna.

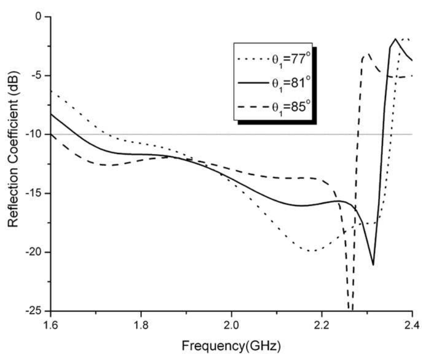

Figure 6. Simulated reflection coefficient, varying θ_1.

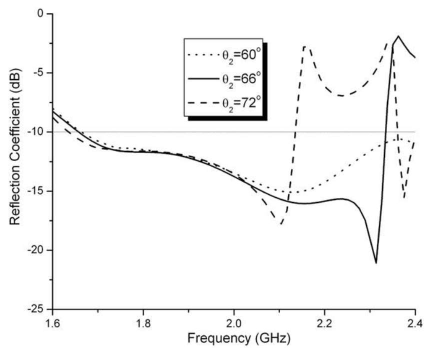

Figure 7. Simulated reflection coefficient, varying θ_2.

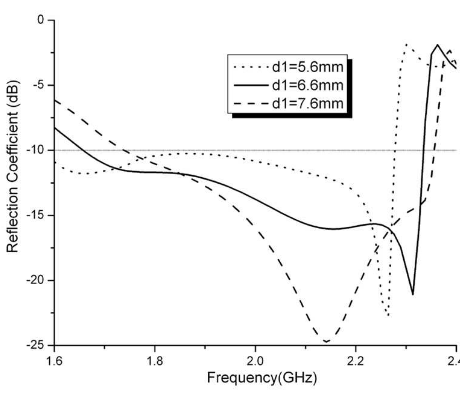

Figure 8. Simulated reflection coefficient, varying $d1$.

Table 2. Details of measured pattern results.

Frequency (GHz)			1.71	1.94	2.17
Azimuth plane	Cross-pol (dB)	+45/ −45	−16.8/ −18.2	−25.7/ −25.9	−17.1/ −18.6
	3 dB beam width (deg)	+45/ −45	63/ 62.5	61/ 61	60/ 60.5
	Front to back ratio (dB)	+45/ −45	38.4/ 38.6	36.5/ 42.3	37.8/ 40.2
Elevation plane	Cross-pol (dB)	+45/ −45	−22.1/ −24.4	−24.8/ −21.9	−17.6/ −19.3
	3 dB beam width (deg)	+45/ −45	69/ 66	63/ 63.5	57/ 58.5
	Front to back ratio (dB)	+45/ −45	35.7/ 40.9	47.6/ 40.3	37.4/ 34.2
Gain (dB)		+45/ −45	8.5/ 8.5	8.5/ 8.6	8.6/ 8.6

4. CONCLUSION

A compact and wideband dual-polarized antenna with good isolation has been designed, fabricated and tested. Parameters of the antenna are also studied. The proposed antenna achieves 34.7% bandwidth for VSWR < 2.0. Actually this antenna contains two pairs of dipoles, and one of them is for $+45^\circ$ polarization and the other for -45° polarization. The size of the whole antenna is only $\pi \times 34^2\,\text{mm}^2$. The isolation between the two ports is better than 29.5 dB over the whole frequency band. The proposed antenna has a relatively flat measured gain of about 8.5 dB over the frequency band mentioned above.

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