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A Modified Microstrip Patch Antenna for Circular Polarizaion

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Abstract: In this paper, a novel design of a microstrip patch antenna for circular polarization is proposed. The novel structure is achieved by embedding circular holes on the microstrip disk resonator. By changing the size and position of these holes, two orthogonal field components with equal amplitude but in phase quadrature are generated. Because the antenna structure is printed on a single metal layer, this antenna can be easily constructed.

I. INTRODUCTION

In satellite and wireless mobile communication systems applications, microstrip antennas have been much attracted due to their low profile, light weight, and easy fabrication [1]. It is usually designed for single-mode operation that radiates mainly linear polarization. In some applications such as satellite communications, however, the circularly polarized system is more suitable because of its insensitivity to transmitter and receiver orientations [2]. For a circularly polarized radiator, a patch must support orthogonal fields of equal amplitude but in-phase quadrature. This requirement can be accomplished by two types of feeding schemes. The first type is a dual-orthogonal feed, which employs an external power divider network. Several power divider circuits that have been successfully employed for circularly polarized generation include the Wilkinson divider, branch-line coupler, and rat-race coupler. This method frequently leads to higher order mode generation and unacceptable spurious feed radiation, which adversely affect the axial ratio performance [3]. Traditional methods of producing single feed circularly polarized antennas include the use of truncated corners, a nearly square patch and the cutting of a diagonal slot within the patch center [4]-[5]. In this paper, an antenna is designed by etching four circular holes on the microstrip disk resonator instead. This allows ease of assembly and packaging. The circularly polarized patch antenna is achieved by offsetting the positions of some of theses holes.

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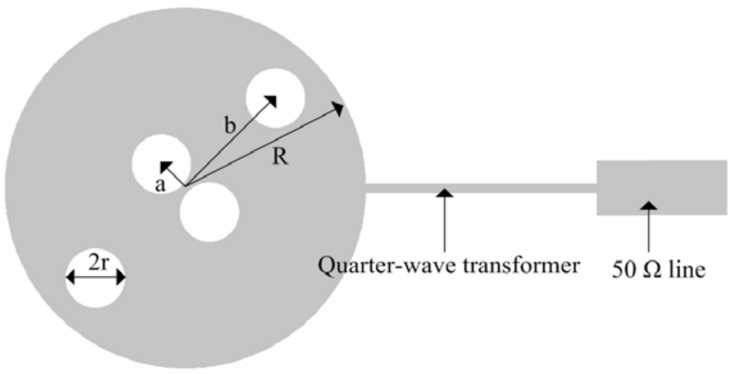

Fig. 1. Schematic diagram of the proposed antenna

II. CIRCULARLY POLARIZED PATCH ANTENNA

The basic geometry investigated in this paper is shown in Fig. 1. This antenna consists of one patch resonator with four holes. The radius *R* of the circular patch is assigned to 6 mm. The hole is a circular shape on the patch resonator. Its radius is denoted by *r*. The holes are etched on the patch at positions *a*, φ=135° and 315°. The others are located at positions *b*, φ=45° and 225°. There is asymmetry in the layout. The thickness and relative dielectric constant of the substrate are 25 mil and 2.5. Simulation is carried out using IE3D, a commercial electromagnetic simulator based on an integral equation method and the method of moment. The resonant frequency of the simple patch without etched holes is designed at 8.87 GHz. To match the antenna impedance well, a quarter-wave transformer is used. The presence of holes extends the length of the current path for a given area thereby reducing the resonant frequency of the antenna. It is similar in configuration to the dual-mode filter [6]. The circular hole is applied as a perturbation element, in the case of the dual-mode filter, to generate the two modes responsible for radiating two linear waves in equal amplitude and 90° phase imbalance.

Initially, the loaded holes are located at *a*=*b*=4.24 mm. The radius *r* is 1 mm. Because of their geometrical symmetry, it becomes linear polarization. Its resonant frequency is 8.61 GHz. To achieve the CP radiation, two pairs of holes with different offsets *a* and *b* is required, as shown in Fig. 1. An offset in the position of the holes, which is located at φ=135° and 315°, will cause the other degenerate mode to be excited. Hence, the amount of offset *a* of two holes will determine the amount of coupling to the other mode. Three circularly polarized patch antennas are simulated with the different offsets *a*. In order to investigate the influence of the offset *a*, the radius *r* of holes and offset *b* are kept is constant to 1 mm and 4.24 mm, respectively. The simulation results are illustrated in Fig. 2. As the offset *a* of the holes is increased, the resonant frequency is slightly decreased and an axial ratio is decreased.

For the cases of the proposed compact dual-frequency antenna with *a*=1.69 mm and *b*=4.24 mm, the comparisons between the simulated and the measured reflection coefficient are shown in Fig. 3. The bandwidth of proposed patch antenna is 3.5 %. This deviation is partially due to the diffracted field at the edge of the substrate, which is not considered in the simulation. The radiation characteristics of the microstrip patch antennas within their operating bandwidths are important design considerations. The radiation patterns are measured at the resonant frequency of f=8.47 GHz. Fig. 4 shows a measured spinning linear far-filed radiation pattern of the proposed antenna. The electrical size of the ground plane is kept approximately 1.2 $\lambda_0 \times$ 1.2 λ_0. A measured gain of 5 dBi is achieved.

III. CONCLUSION

The circular holes are etched off the conductor surface of a microstrip circular resonator. The circular polarized behavior of the proposed patch antenna can be flexibly controlled by adjusting the size and offset of loaded holes. The measured 10-dB return loss and 3-dB axial ratio bandwidth of the proposed broad-band antenna are 3.5 % and 2.5 %, respectively. The proposed antenna shows good agreement between simulated and measured results. These antennas are suitable for applications in wireless communications and mobile satellite communications.

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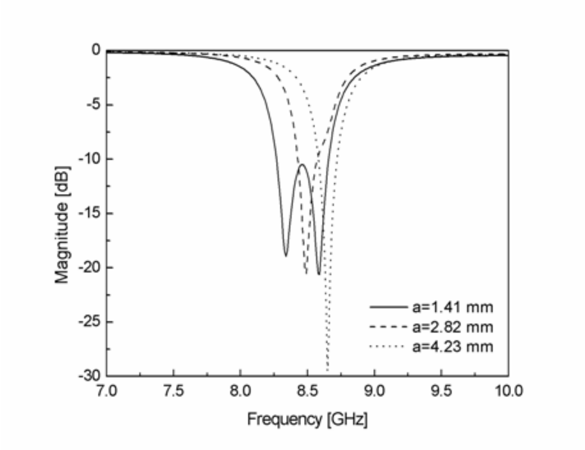

Fig. 2. Simulation results of the proposed antenna with different offsets *a*.

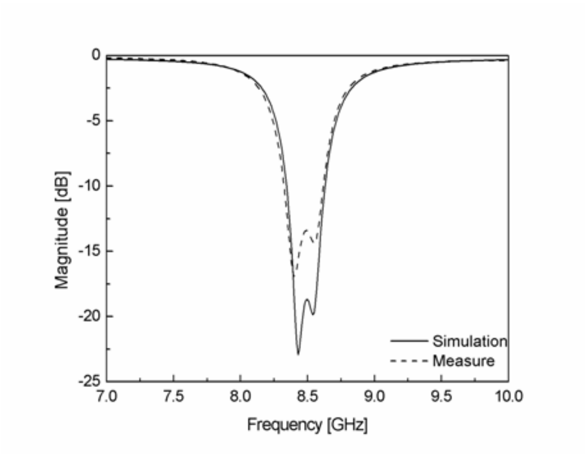

Fig. 3. Simulated and measured results of the proposed patch antenna.

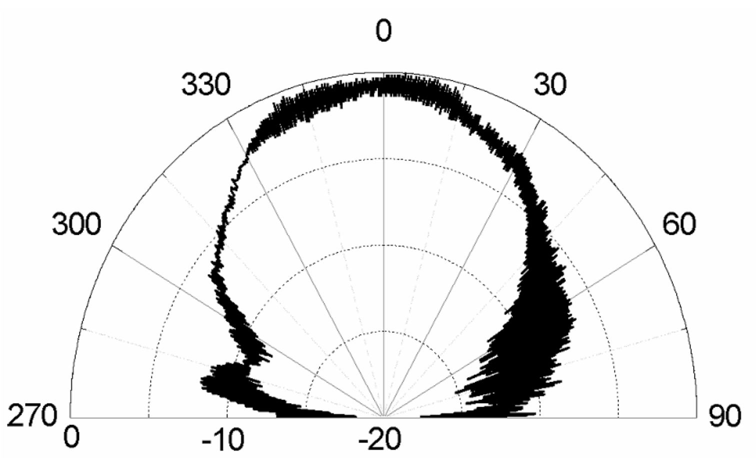

Fig. 4. Radiation pattern of the patch antenna.