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Asymmetrically Loaded Circularly Polarized Patch Antenna for 2.4 GHz Applications

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***Abstract*: This letter presents the design of circularly polarized patch antenna for 2.4 GHz applications. Parasitic patch within the circular slot located on the first quadrant induced the circularly polarized radiation. Symmetric slits are introduced along the four sides of the radiator to enhance the magnitude of axial ratio. The antenna occupies an overall volume of 50 x 50 x 1.6 mm and achieves a 3-dB axial ratio bandwidth of 37.1MHz with 10-dB impedance bandwidth of 102.5 MHz. The prototype antenna is fabricated and the simulated results are verified using measurement results.**

***Keywords*: Circular Polarization, axial ratio, micro-strip antenna, impedance Bandwidth**

1. Introduction

Indoor Navigation Systems are currently one of the growing industrial markets and demands efficient antennas with suitable specifications. Portable navigation devices generally require a low profile circularly polarized microstrip patch antenna with a considerable gain. The orientation between the transmitter and receiver antenna does not affect the signal transmission in case of circularly polarized microstrip antenna. Also, the losses in signal quality due to multipath effects are reduced to a larger extent in circularly polarized antenna design [1]. Circular polarization can be obtained using either single feed or dual feed systems. The dual feed mechanism [2] requires an additional power divider to induce CP radiation at the cost of increased antenna dimension. The single feed antenna has low gain and narrow bandwidth but still they are compact and can be easily integrated with portable devices [3]. On creating perturbation at appropriate locations on the radiating patch, two orthogonal modes with 90-degree phase shift can be produced which results in CP radiation [4]. In literature there are number of techniques have been proposed to achieve circular polarization and improving the axial ratio bandwidth. Several methods has been proposed in the literature for introducing perturbation such as truncating the corner [5], asymmetric slots [6], symmetric slits [7], slits along the diagonals. High permittivity superstrate loading [8] also produces CP radiation but at increased antenna size. Loading of shorting pins along the patch [9] causes shunt inductive effect, creating circular polarization with high gain but the design complexity increases and the fabrication losses are significant.

In this letter, single fed circularly polarized patch antenna is proposed for 2.4 GHz WLAN applications. A circular slot along with a parasitic semi circular patch on the first quadrant induced the circular polarization from the antenna. To further enhance the magnitude of axial ratio symmetric slits on the edges are introduced.

This letter is organized as follows. Section II describes the evolution of the proposed CP antenna and Section III outlines the detailed parametric study on various parameters. Measured results are discussed in section IV and section V presented with the conclusion.

2. Proposed antenna design

The geometric description of the proposed circularly polarized patch antenna is depicted in Figure1. The overall dimension of the antenna is 50 x 50 x 1.6 mm, with a square radiating patch of 27.87 mm. The antenna is fabricated on a FR-4 substrate (Ɛr = 4.3, loss tangent=0.025). The radiator is fed with a coaxial feed along the x-axis at 7mm from the centre. A circular slot along the diagonal of the patch in first quadrant with four symmetric slits along the edges and an embedded parasitic element inside the circular slot makes the radiating patch asymmetric. Two orthogonal modes with equal amplitude and a 90-degree phase shift is required for CP radiation, which is obtained by adding the parasitic element inside the circular slot along with the slits which results in meandering of surface current path.

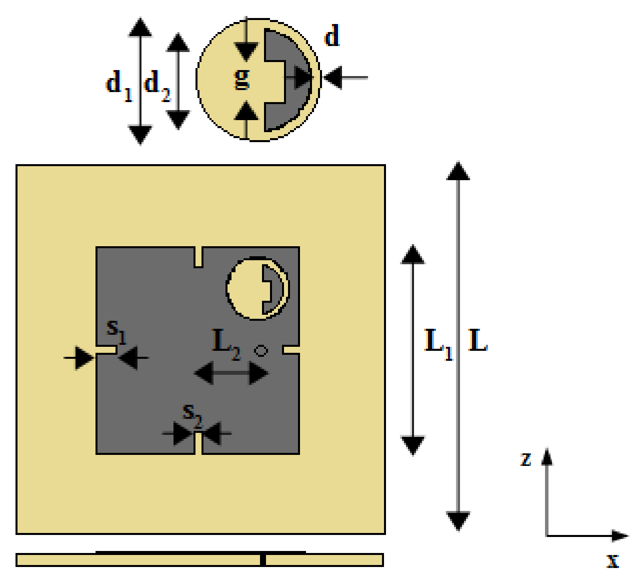


Fig. 1. Proposed circularly polarized microstrip patch antenna

The dimensions of the slot, slits and the parasitic patch are given in table 1.

Table 1
dimensional details of the proposed antenna

Parameters	L	L_1	L_2	d_1	d_2	s_1	s_2	g	d
Values	50	27.87	7	4	3.5	1	2	1	0.5

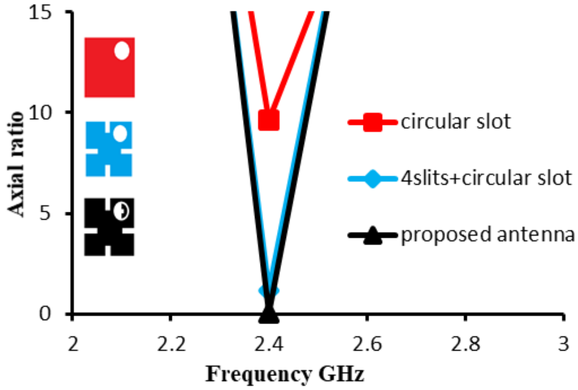


Fig. 2. Evolution of the proposed antenna

The evolution of the proposed antenna is illustrated in Fig. 2. The simulated results of various loading structures during the evolution are presented. Circular slot along the diagonal axis of the radiating patch produces an axial ratio of 9.6 at 2.4GHz (red curve). By adding four symmetric slits on each sides of the radiating patch, it is observed that the axial ratio has reduced to 1.15 (blue curve). Further, embedding a parasitic element inside the circular slot provides a very low axial ratio of .05 along with good impedance matching (black curve). Also, it is found that the 3dB axial ratio has been increased on addition of this parasitic element inside the slot.

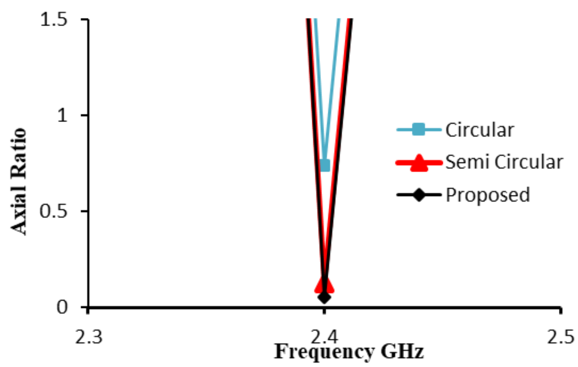


Fig. 3. Simulated Axial Ratio for various parasitic patches

3. Results and discussion

A. Effect of parasitic patch on axial ratio

The parasitic patch inside the circular slot has a larger impact on the axial ratio. Various shapes of parasitic patch have been embedded and the results are presented. Lowest axial ratio is obtained with the semicircular parasitic element with the slits which are evident from Fig. 3.

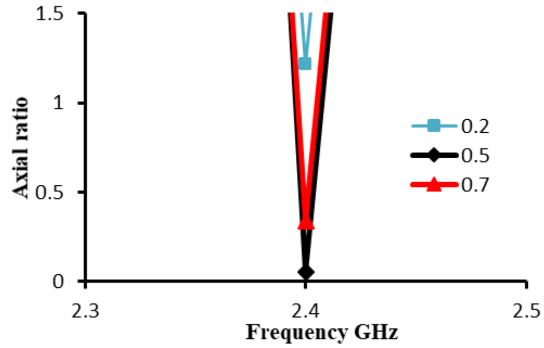


Fig. 4. Simulated Axial Ratio for varying the location of the parasitic element

B. Effect of the location of the parasitic element on axial ratio

On slightly varying the position of the parasitic element along x-axis (d) inside the circular slot the axial ratio and impedance matching changes to some extent as shown in Fig. 4. On placing the parasitic patch concentric to the circular slot such that the gap between them is 0.5mm, very low axial ratio of 0.05 was obtained.

C. Effects of ground plane on axial ratio

The following results shown in figure 5 were obtained on varying the ground from 45 mm to 55 mm and it was found that on increasing the ground from 55 mm to 50 mm a low axial ratio of 0.05 was obtained. Further decrement in the ground size has negative effect on axial ratio as it increases. The axial ratio was best obtained when the ground is 50 mm x 50 mm.

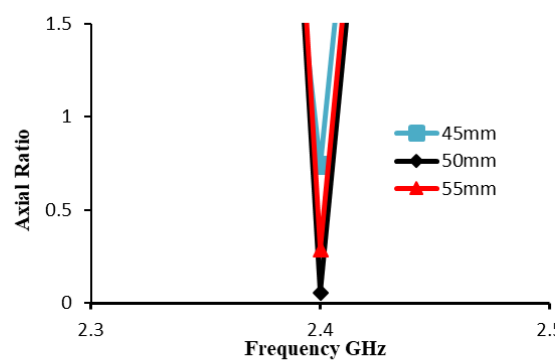


Fig. 5. Axial Ratio for variation dimension of ground plane

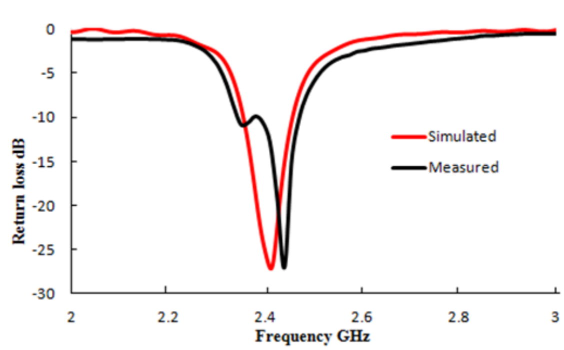


Fig. 6. Measured and Simulated reflection coefficient characteristics of the antenna

Fig. 7. Fabricated Prototype of the antenna

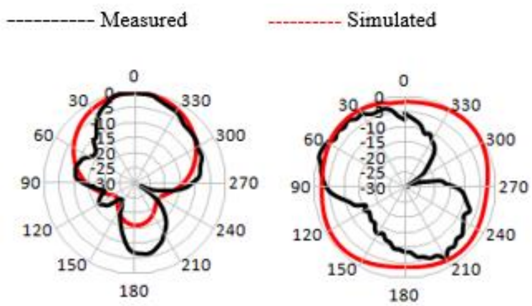


Fig. 8. Measured radiation pattern of the proposed antenna

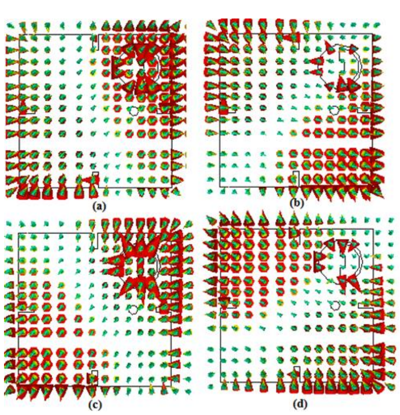
4. Experimental results

The reflection coefficient characteristics of the antenna are measured using Agilent's 85052 D Vector Network Analyzer. All the cable losses are included in the measurements and the results are shown in Fig. 6. From Figure it is evident that the measured results are in good agreement with the simulated results.

Fabricated prototype of the antenna is shown in Fig. 7. To verify the suitability of the antenna for CP radiation, radiation pattern measurements were taken at 2.4 GHz. Standard gain horn antennas are deployed under reflection free environments and the principle patterns are taken which is shown in Fig. 8. It can be seen that the radiation pattern in the xz – plane is nearly omni-directional.

The CP radiation of the designed antenna can be confirmed from the surface current distribution shown in Fig.9.

From comparison the proposed circularly polarized microstrip patch antenna design has very low axial ratio of 0.05 which is a good candidate for CP radiation in 2.4GHz range.



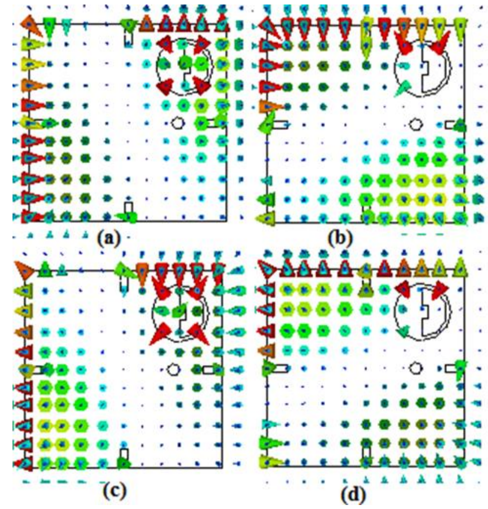


Fig. 9. Surface current distribution at 0, 90, 180, 270 degree respectively

5. Conclusion

A Circularly polarised antenna for 2.4GHz applications is proposed in this letter. A unified approach has been proposed to effectively enhance the axial ratio of the design by conducting parametric studies. Parasitic patch within the circular slot along with symmetric slits provides the axial ratio magnitude of 0.05 at the operating frequency. The antenna provides ARBW of 37.1 MHz (2.3861-2.4232GHz) and 10-dB impedance bandwidth of 102.5 MHz (2.354-2.456GHz).

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