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Flower Shaped Slotted Microstrip Patch Antenna for Circular Polarization

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Abstract : *In this paper we proposed flower, cross-circle and L-shaped slotted microstrip patch antenna for circular polarized (CP) radiation suitable for ISM band applications. The cross-circle diagonally symmetric slotted microstrip patch antenna is compact and providing best result when compared with flower and L-shaped diagonally symmetric slotted microstrip patch antenna. The antenna is compact, lightweight and of low cost. The proposed antennas of size 50mm*50mm*1.570mm at 2.45 GHz is printed on thick FR4 substrate with probe fed metal strip. Fabricated prototypes offers very low return loss, desirable matched impedance, high gain and good 3-dB axial ratio bandwidth, which is approximately matching with the simulated results.*
Keywords - *Circularly polarized antennas, compact antennas, microstrip antenna, square patch, slotted microstrip antennas.*

I. Introduction

Compact circularly polarized microstrip antennas are widely used in handheld portable devices and in compact mobile communication systems. Circular polarization is one of the most common polarization types used in current wireless communication systems. Many applications also need compact circularly polarized microstrip antennas where the overall antenna size is a major consideration, such as for radio frequency identification (RFID) readers, mobile wireless, receiver antennas for medically implanted applications and portable wireless devices [1-6]. Single and dual-feed structures are generally used in the design of circularly polarized microstrip antennas. Single feed circularly polarized microstrip antennas are usually more compact when compared to dual-feed circularly polarized microstrip antennas [7]. The dual-feed structure needs a larger ground-plane area for the feeding-network circuit (external polarizer) than does the single-feed structure, but the dual-feed structure provides a relatively larger bandwidth [2]. For circularly polarized radiation, the single-feed-based microstrip antenna configuration needs a slightly slotted patch structure at appropriate locations with respect to the feed location to excite two orthogonal modes having 90° phase difference [1].

For size reduction of the antenna, four symmetrical slots along the orthogonal directions of the circular-shaped slotted patch radiator were used [1]. In this paper, a method is proposed to generate circularly polarized radiation with compact size of the square microstrip antenna using a diagonally symmetric slotted microstrip – patch structure [8-13]. The proposed method is based on symmetrically embedded slots along the diagonal directions on the microstrip square-patch [14]. Circularly polarized diagonally symmetric slotted microstrip-patch antennas are proposed and studied based on circular, L and cross-shaped slots. By slightly varying the perimeter of the slots in the diagonal directions of the square patch, circularly polarized radiation can be obtained [3-4]. The measured results are compared with simulated results.

II. Antenna Geometry

The structure layout and design parameters of the proposed microstrip patch antenna are shown in figures (1-4). The antenna is designed and fabricated on copper plated substrate, fiberglass polymer resin (FR4) substrate of thickness h=1.5mm with relative dielectric constant ε_r = 4.4 and loss tangent tanδ = 0.02. The two-sided structure of the antenna consists of a standard 50Ω SMA connector, a cylindrical gap for coaxial feed line, radiating patch on top and square ground plane of 50mm*50mm on the other side. The final structure is achieved by cutting slots and etching out different shapes from the square patch [9-13]. Dimensions Length (L) and Width (W) are calculated from the expressions given in [15-16], where same expressions given for rectangular patch are used for square patch by keeping L=W. Different slots are made by optimization method to obtain the proposed antennas. The IE3D simulator was used for the design and optimization of structure and fabrication is done using LPKF protomat S100.

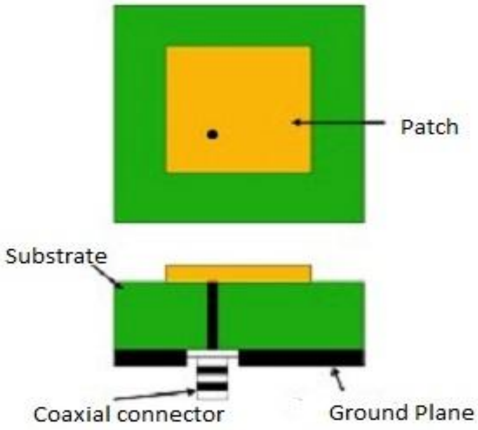


Figure.1 Coaxial Probe Feed

III. Structure Specifications

Parameter	Lp	W	L	C1	D
Value(mm)	27.9965	50	50	8	5

Table.1: Parameters of optimized structure- Cross-Circle

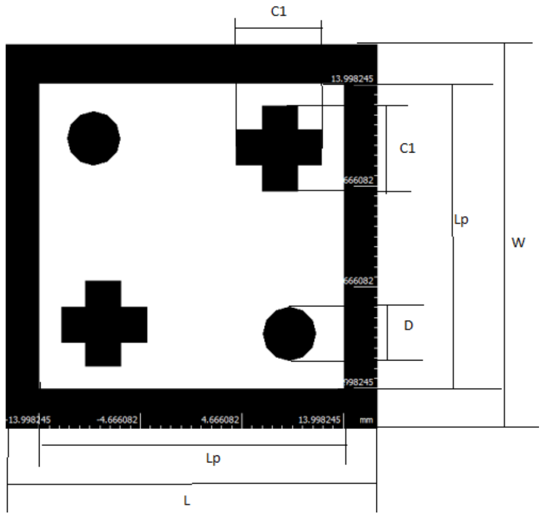


Figure.2 Cross-Circle Slot Configuration

Parameter	Lp	W	L	C1	D	L1	B1
Value(mm)	27.9965	50	50	8	4	4	1

Table.2**:** Parameters of optimized structure- L-Slot

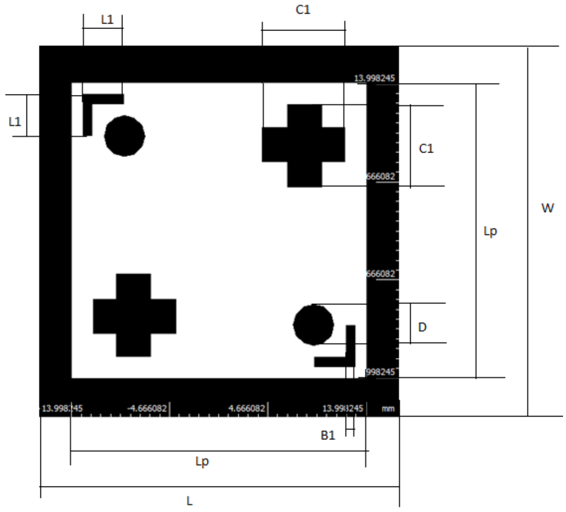


Figure.3 L-Slot Configuration

Parameter	Lp	W	L	C1	D	L1	B1
Value(mm)	27.9965	50	50	8	4	3	1

Table.3: Parameters of optimized structure- Flower-Slot

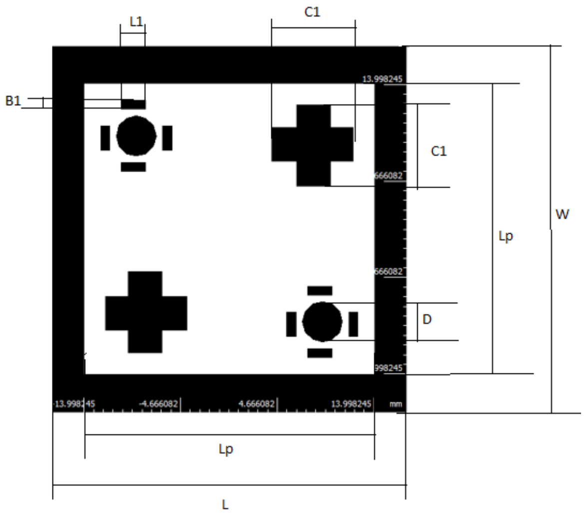


Figure.4 Flower-Slot Configuration

IV. Experimental Validation And Discussion

The proposed structures of figure (2-4) were fabricated for practical applications. The dimensions of the fabricated structures are listed in the above tables. Input characteristics of the prototypes of the test antenna are measured with the help of vector network analyser (VNA) and spectrum analyser. Photographs of fabricated microstrip patch antenna for different slots are shown in figure 5. Etching of circular, cross and L shapes from radiating patch are responsible for creating disturbed path for the surface currents which is responsible for generating circular polarization at different resonant frequencies [14]. Effect of etching different slot shapes from patch is examined by return loss characteristics. Comparisons in simulated & measured return loss characteristics are presented in figures 6(a-c). From these comparison graphs it may be noted that there is a good agreement between the simulated and measured values out of which cross-circle configuration has the best agreement giving S11(simulated)= -23.886dB, S11(measured)= -25dB, AR= 0.5dB, gain= 3.3336dB. Figure 7(a-b) shows the gain and axial ratio vs. frequency plot characteristics. Peak gain and axial ratio obtained are 3.3 dBi and 0.5dB at 2.45GHz, these values indicate proper operation of the proposed antenna structures.

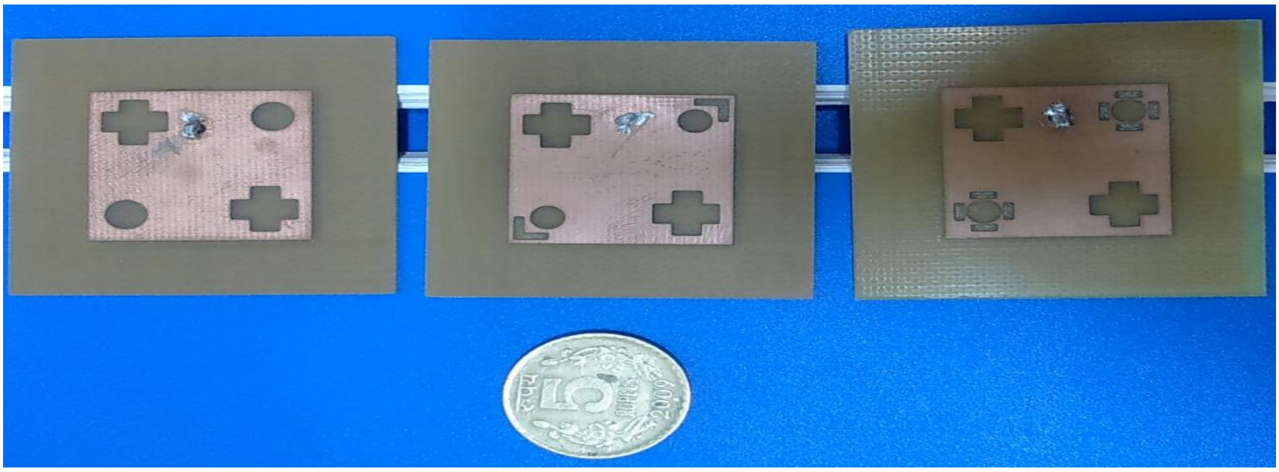


Figure. 5

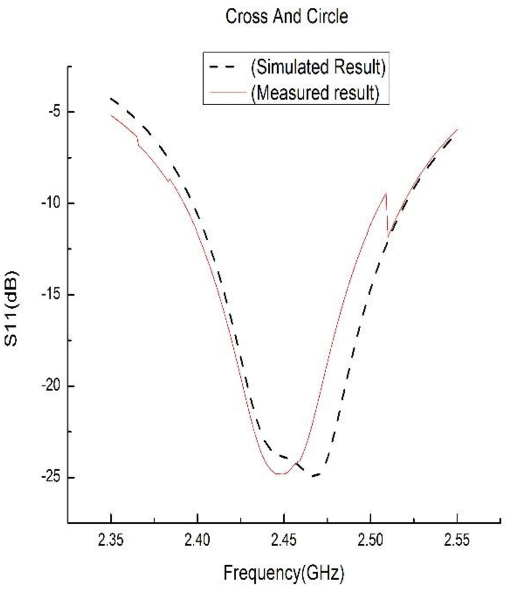


Figure.6(a)

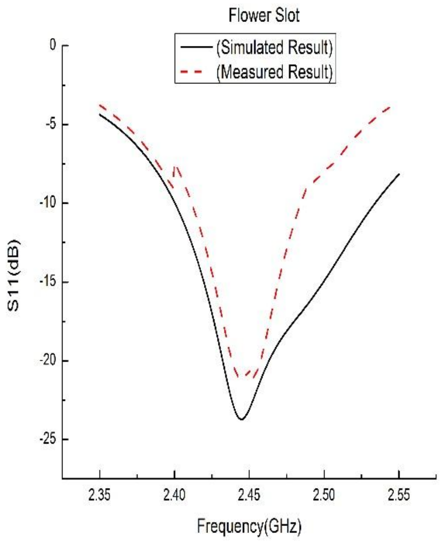


Figure.6(b)

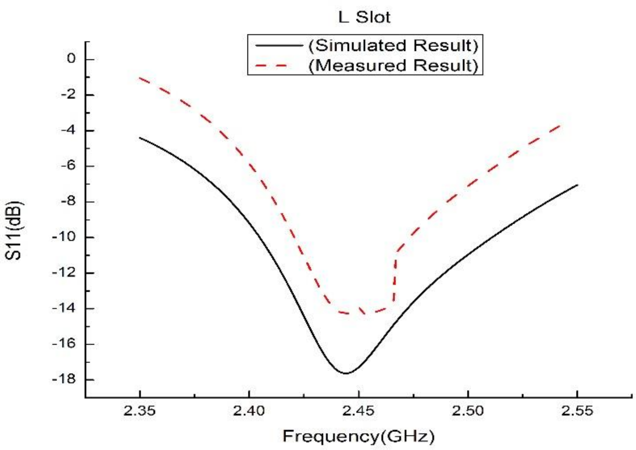


Figure.6(c)
Measured and simulated S11 characteristics

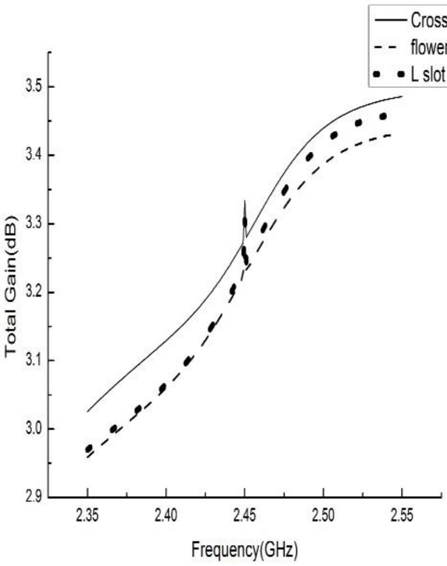


Figure 7(a). Gain vs frequency

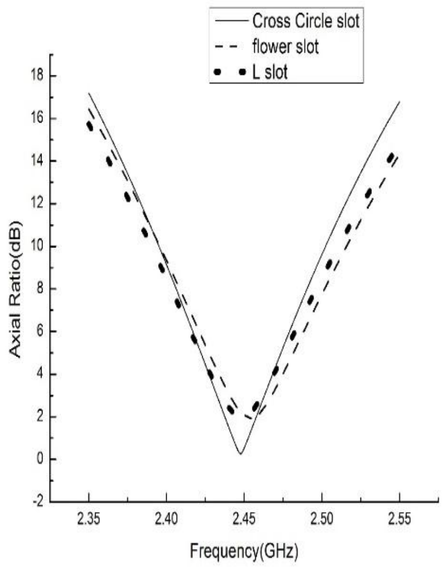
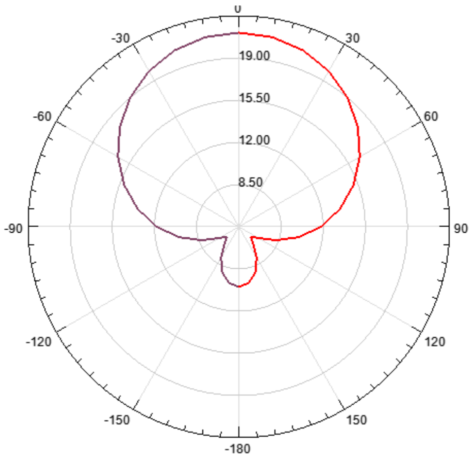
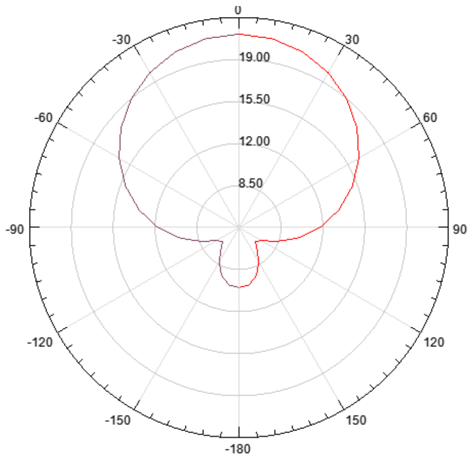


Figure 7(b). Axial ratio vs frequency



(a) Phi = 0 degree



(b) Phi = 90 degree

Figure. 8 Radiation patterns of Cross-Circle configuration at frequency = 2.45 GHz

V. Conclusion

Compact circularly polarized diagonally symmetric slotted microstrip patch antennas have been studied and presented based on different shaped slots. Any arbitrarily shaped slot can be used to achieve circularly polarized radiation with an antenna of compact size. The cross-circle shaped diagonally symmetric slotted microstrip patch antenna for circularly polarized radiation is the best when compared with other two slots. It has been shown that by changing the relative perimeters of the slots, the operating frequency band of the antenna can be tuned with good circularly polarized radiation for a desired operating frequency. So the microstrip patch antenna for low return loss, high gain and high 3-dB AR bandwidth has been fabricated and experimentally achieved for ISM band applications. The above mentioned capabilities of the antenna has been achieved by cutting slots of various shapes (cross-circle, L and flower slot). Measured results (S_{11}) agree with the simulated values. From the experimental results it is clear that the cross-circle configuration among the fabricated structures offers high 10-dB return loss bandwidth of 5% (2.38 to 2.50 GHz) and 3-dB axial ratio bandwidth of 2% (2.435 to 2.465 GHz).

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