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# Axial Ratio Bandwidth Enhancement of Micro Strip Patch Antenna with Circular Slot and Square Ring

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**Abstract:** A circularly polarized antenna with large axial ratio bandwidth has been proposed in this work. The antenna is designed by a 45$^o$ slot cut and a circular opening in the center of the square patch anda square metallic ring around it. It can achieve a 3-dB axial ratio Bandwidth of 110 MHz with impedance B.W of 56 MHz as compared to the antenna without a metal square ring is 35MHz.This antenna can be successfully applied for wireless application.

**Keywords:** Microstrip Antenna, Axial ratio bandwidth, return loss, circular polarization.

## I. INTRODUCTION

Antenna is a means for radiating or receivingradio waves. The electric field plane determines the polarization or orientation of the radio wave. In general, most antennas radiate either linear or circular polarization.

Microstrip patch antennas are most popular antennas forwireless communication, as they offer the benefits of low profile, light weight, compact, conformabletosurfaces, easyfabrication.Microstrip antennas have the inherent disadvantages oflow gainand narrowbandwidth. A linear polarized antenna radiates wholly in one plane containing the direction ofpropagation. In a circularpolarizedantenna, theplane ofpolarization rotates inacirclemaking one completerevolution during one period of the wave. If the rotation isclockwise looking in the direction of propagation, thesense is called right-hand-circular (RHC).[2] If therotation is counter clockwise, the sense is called left-handcircular(LHC).Circular Polarized antennas (referredto asCPantennashereafter)areincreasinglygainingimportancei nwirelesscommunications since they allow signal reception irrespectiveoftheorientationofthereceiveantennawithrespec ttothetransmitantenna, andalsohavetheabilitytosuppress multipath interference. Linear polarized antennasrequiretransmit and receive antennas to be of the same polarization, hencerequireaccuratealignmentoftheantennas.
Circularpolarized microstrippatchantennasarewidely used inportable/ hand held devices, for example RFID reader antenna, WLAN, GPS, rectennaforenergyharvesting, mobilephone antenna, etc.

**Circular Polarization**: In acircularly polarizedantenna, the plane of polarization rotates in a corkscrew pattern, making one complete revolutionduringeach wavelength. Acircular polarized waveradiates energy in both the horizontal and vertical planes and all planes in between. If the rotation is clockwise looking in the direction of propagation, the sense is called right-hand-circular (RHC). If the rotation is counterclockwise, the sense is called left-hand circular (LHC).

AdvantagesofCircularPolarization: Due to the advanced signal propagation properties, CPantenna technology offers numerous performance advantages over traditional linear technologies. When implemented as a central component within a Wi-Fi network, CP delivers betterconnectivitywith both fixed and mobile devices and ultimately leads to a superior user experience. CP is ideal for addressing challenges associated with mobility, adverse weather conditions, and non-line-of- site applications.

In this paper, a CP microstrip antenna with large 3dB AR bandwidth has been proposed. Firstly, a microstrip antenna with a square patch is designed and taken as reference antenna. Secondly, a 45$^o$ rectangular slot is cut in the center of the patch.
Finally, a circular cut at the center of the patch and a square metallic ring is inserted in the second structure's characteristics of the final structure are compared with second antenna. These antennas are first characterized with the ANSYS-Ansoft high-frequency structure simulator (HFSS).

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## II. ANTENNA DESIGN AND RESULTS

Figure 1 shows the structures of proposed MPAs. A conventional MPAs is shown in Fig 1.a.Based on this,two CP MPAs are proposed. In Figure 1(a), a conventional MPA is given. The results obtained are taken as referencefor two proposed structures having same dimensions of the ground plane andprinted patch as shown in the figure.FR4 is taken as the substrate with a thickness of 1.2 mm,relative permittivity of 4.4 and loss tangent of 0.02 for all structures.

The model in Figure 1(b) is derived from Figure 1(a); a $45^{o}$ rotated slot has been cut in the center of the square MPA. The length and width of the slot are $6\sqrt{2}$ and $\sqrt{2}$ mm respectively. The dimensions of the MPA has been properly optimized to 28 mm which corresponding to $0.224\lambda_o$ in air at 2.45 GHz.InFig. 1(c), a printed ring is symmetrically placed around the patch and a circular cut on patch is made along with rectangular slot as shown in figure. Metallic ring is separated from patch by a distance of 1.4mm. Ring width is 1.2mm.Feed point for all the structures is 6.5 mm from edge.The antenna is fed through the feed points welded with 50-ohm coaxial cables.

### 2.1. ANTENNA DESIGN

The essential parameters for the design of a Microstrip patch antenna are [8]:

1. Calculation of width(W):

$$W = \frac{c}{2\ f0\sqrt{\frac{\varepsilon r+1}{2}}}$$

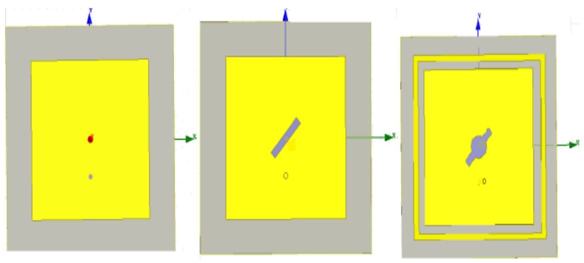
Where c is the velocity ofEM wave i.e., $3X10^{8}$ m/s.
Putting these values,W=28mm.

2.
3. Calculation of effective Dielectric constant εreff

$$(\varepsilon reff) = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} . 1/\sqrt{\left[1+\frac{12h}{w}\right]}$$

4.
5. For W/h >1,

$\Delta L / h = 0.412(\varepsilon_{reff} + 0.3)(W/h + 0.264)$
$(\varepsilon_{reff} - 0.258)(W/h + 0.8)$



(a) (b) (c)

Fig: 1: Geometry of (a) reference microstrip Patch antenna (b)MPA with a $45^{o}$ rotated slot cut (c)MPA with a circular cut and a square ring structure.

### 2.2. RESULTS

Antenna 1, 2 and 3 is shown in figure 1.Fig 1(a) is the reference which is a conventional patch antenna, Antenna 1(b) consists of a rectangular slot in the Centre of the patch.In fig 1(c), a circular cut at the Centre and a square ring around the patch is inserted. Simulated results for all three antennas are shown in figure 2, 3 and 4 respectively. Antenna 1 is considered as reference antenna and its Impedance bandwidth is better than 10 dB from2.457GHz to 2.518 GHz. For antenna 2, simulated result shows that impedance bandwidth is 107 MHz (2.393 GHz 2.500 GHz) and 3-dB axial ratio bandwidth is about 35 MHz[2.445 GHz-2.480 GHz]. For antenna 3,3-dB axial ratio bandwidth is 110MHz(2.438 GHz-2.548GHz) which covers 2.4 GHz ISM band. Proposed structures show wider bandwidth and lower center frequency.

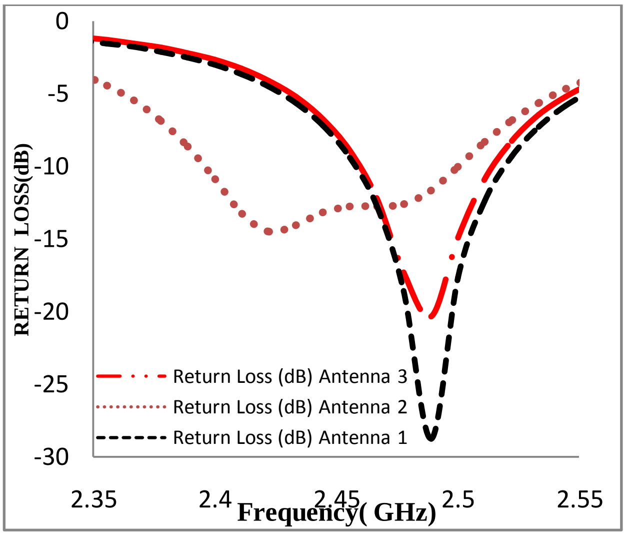



Figure 2: Simulated returned loss for antenna 1, antenna 2 and antenna 3.

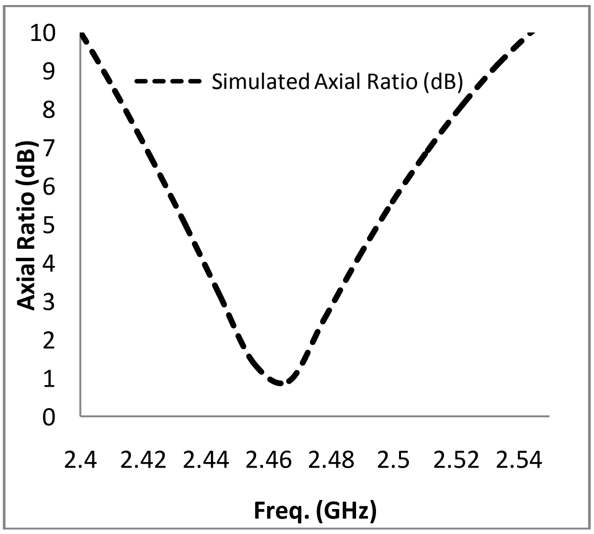



Figure 3: Simulated Axial ratio bandwidth for antenna 2.

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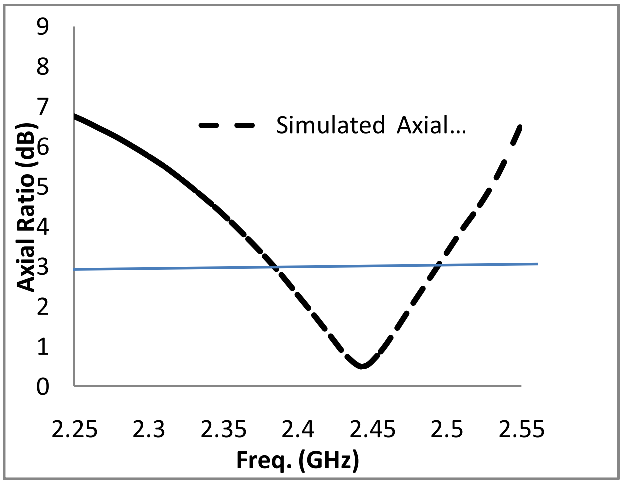


Figure 4: Simulated Axial ratio bandwidth for antenna 3.

Table 1 showing simulated results of all the structures.

| Structure | Freq (GHz) | Return Loss (dB) | S11 Bandwidth (MHz) | AR Bandwidth (MHz) | VSWR |
|---|---|---|---|---|---|
| 1 | 2.49 | -24 | 60 MHz | - | 1.088 |
| 2 | 2.42 | -24 | 107 MHz | 35 MHz | 1.8 |
| 3 | 2.45 | -21 | 56 MHz | 110 MHz | 1.169 |

## III. CONCLUSION

This article proposed a novel circularly polarized microstrip patch antenna with enhanced 3-dBaxial ratio bandwidth. By introducing the square ring and $45^0$ rotated slot cut along with a circular slot cut, enhanced bandwidth can be achieved. The simulated results are given.3-dB axial ratio bandwidth of the proposed antenna is 110 MHz.The proposed antenna can be used for the wireless system.

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