

# A Dual Band, Dual Polarized Slot Antenna Using Coplanar Waveguide



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**Abstract** This letter presents a multiband antenna exhibiting dual polarization characteristics. The antenna consists of a circular-shaped slot etched in the ground plane. A rectangular patch is inserted in the slot energized by CPW feed. Three conducting strips are attached to the radiating patch on either side of the feed line along with a circular slot notched on the patch for introducing asymmetric excitation. Further, a number of rectangular slits are embedded in the ground plane protruding into the circular slot for achieving dual polarization characteristics. Asymmetric excitation results in generation of circular polarized radiations for the lower band while the upper band remains linearly polarized. Overlapping lower band i.e.  $S_{11} < -10$  dB and Axial ratio  $< 3$  dB extends from 2.33 to 3.90 GHz while the linear polarized upper band extends from 5.4 to 6.3 GHz thereby proposed antenna covering Bluetooth and WLAN usable bands by dual resonating bands.

**Keywords** Coplanar waveguide · Dual polarized · Slot antenna · Circular slot  
Dual band

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## 1 Introduction

With the age of growing wireless communication system, multiband antennas are highly entertained these days by researchers. In [1] a dual band antenna, operating in GSM band and WLAN band has been proposed with dual polarizations, i.e., lower band circular polarized and upper band linear polarized. In [2], another dual band antenna is proposed with both bands circular polarized. Multiband antenna with multiple polarization characteristics have become prominent [3, 5] and various techniques are used to enable the same antenna to radiate both circular polarized and linear polarized radiations. In [3], stacked-patch triple band antenna exhibiting dual polarization has been presented. In [4], a dipole-like structure has been studied with tapered arms and an open-ended slot resulting in dual band antenna with lower band circular polarized and upper band linear polarized. Similarly, in [5], a sector-shaped coaxial fed antenna with truncated corners is introduced to integrate both linear polarized and circular polarized characteristics in the same antenna, thereby the same antenna radiates both linear polarized and circular polarized radiations.

## 2 Antenna Configuration

Schematic view of the antenna along with its geometrical dimensions is presented in Fig. 1. Antenna presented is a 35 mm × 35 mm structure designed on FR4 substrate of height 1.6 mm, dielectric constant 4.4 and loss tangent 0.02. The antenna is fed by a 50 Ω feed line of width 3.2 mm placed at 0.4 mm from ground. The signal strip is attached to the stair-shaped patch energizing the antenna. A circular-shaped ground is used with a circular notch created in the patch to improve dual band nature. A key feature of the proposed antenna lies in use of circular ground which along with asymmetric patch results in very easy generation of circular polarization and dual band characteristics. The antenna is modeled on CST Microwave Studio and its key antenna parameters are optimized for acceptable values. Couple of rectangular stubs attached to the radiating patch is responsible for generation of two orthogonal electric field components in phase quadrature which generates circular polarized radiations. Nonuniform perturbation of conducting slits into the circular slots helps in tuning the axial ratio bandwidth (Table 1).

## 3 Parametric Study and Antenna Evolution

Antenna prototypes shown in Fig. 2 illustrate the steps involved for antenna improvement. It is evident that the proposed antenna starts resonating when primary stub was introduced in the slot but it was not working as a circular polarized antenna due to high value of axial ratio. After the introduction of rectangular stubs on the diagonally

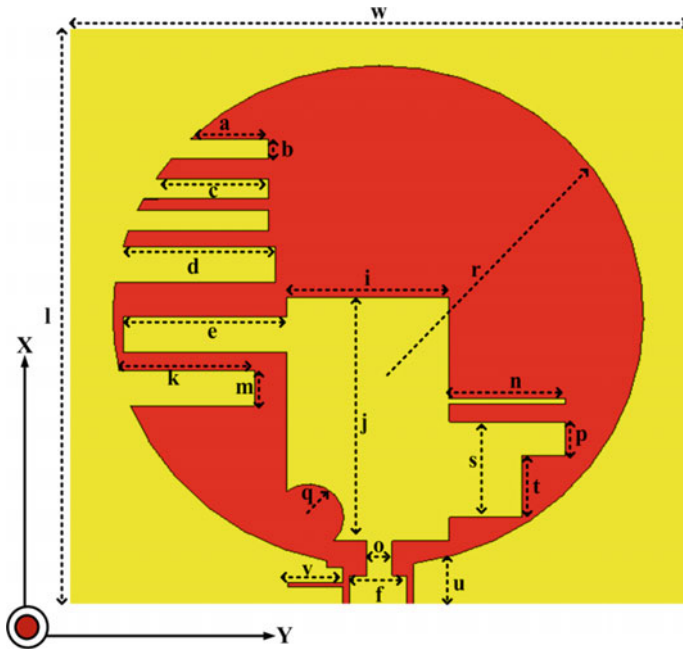


Fig. 1 Schematic view of antenna

Table 1 Antennal dimensions (mm)

a	b	c	d	e	f	h	i	j	k
4.4	1.2	6.4	8.7	9.2	3.2	1.6	9.2	14.6	7.6
l	m	n	o	p	q	r	s	t	u
35	2.1	6.6	1.43	2	2	15	5.7	3.7	2.7
v	w								
3.1	35								

opposite ends of the primary stub, the proposed antenna starts resonating for a wide range of frequencies and axial ratio suddenly drops below but still remains greater than 3 dB which indicates that the necessary condition of exciting orthogonal components of same amplitude but 90° out of phase in time is fulfilled. Now, number of rectangular metallic stubs embedded in the ground are introduced into the circular slot with stubs remaining in the close vicinity of the radiating patch which reduces the axial ratio below 3 dB. Dual polarization characteristics are introduced in the structure by incorporating a circular notch in the radiating patch. From the distribution of surface current for various time instants, it can be observed that current vectors on the patch and ground plane follows an anticlockwise rotation which adds to the RHCP nature of antenna.

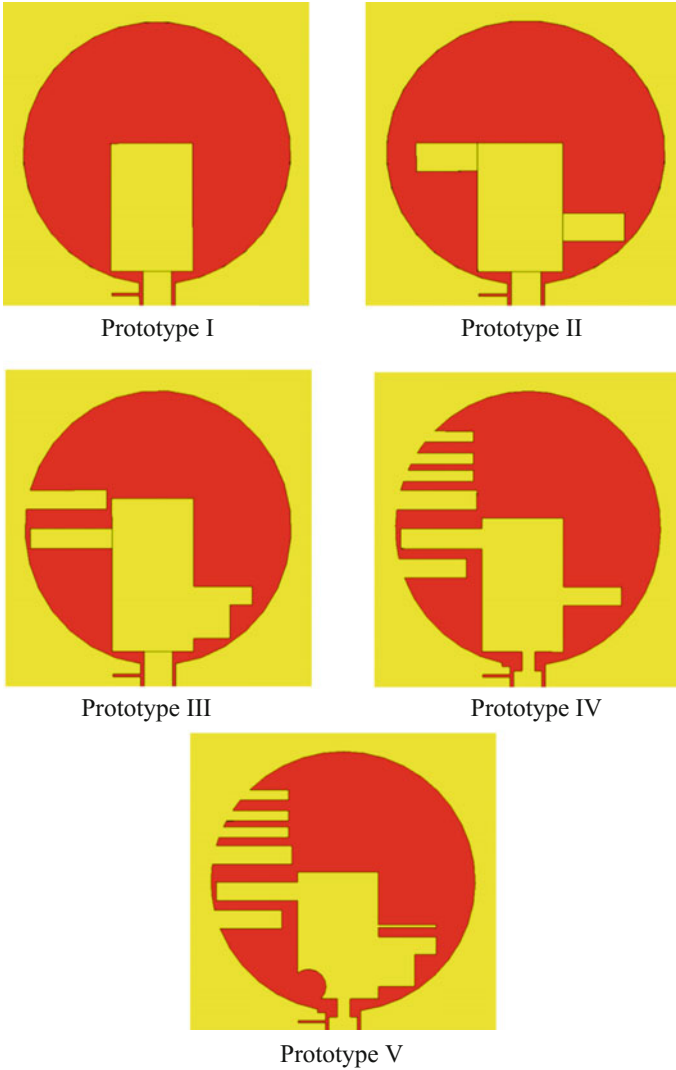
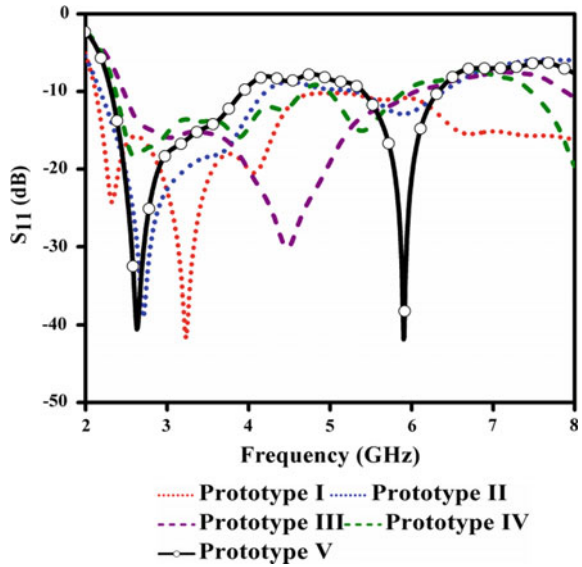


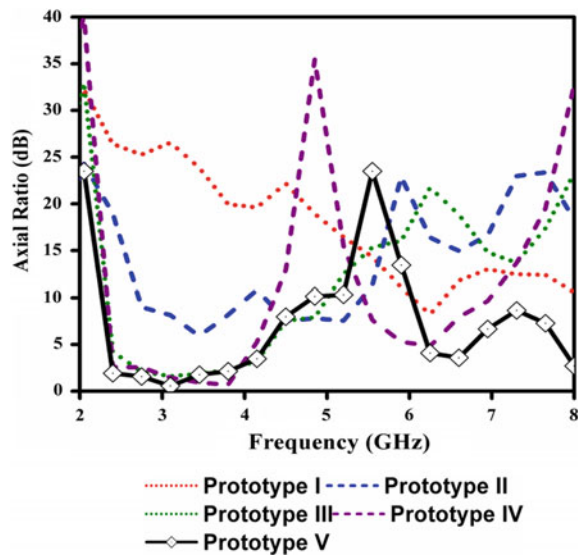
Fig. 2 Steps for improvement of antenna

So it can be inferred that the crucial parameter for circular polarized behavior of the proposed antenna is the circular smooth ground and proper placement of rectangular stubs into the slot leading to asymmetric excitation. Figures 3, 4 show  $S_{11}$  (dB) and axial ratio (dB), respectively, for all the antenna prototypes which show the step by step improvement of antenna. From Fig. 4, it is evident that asymmetric excitation in Prototype IV results in obtaining dual polarization characteristics of the proposed antenna.

**Fig. 3** S-parameter of antenna prototypes

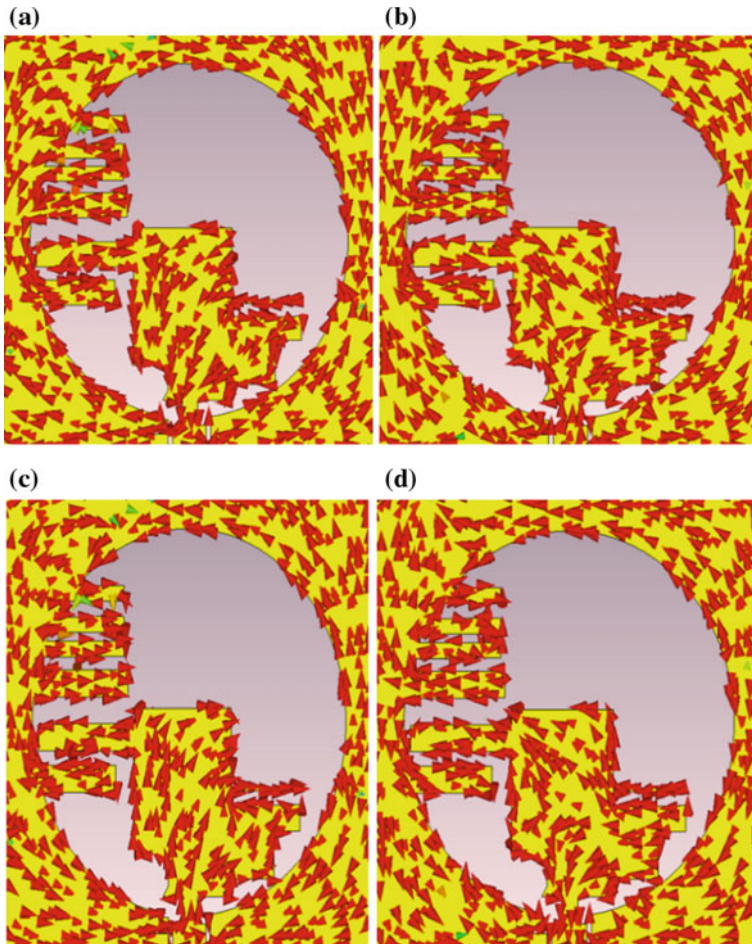


**Fig. 4** Axial ratio of antenna prototypes



### 3.1 CP Analysis

Study of surface current distribution with advancing time also helps in analyzing circular polarized behavior of the antenna. For a circular polarized antenna, current vector follows a circular path as it rotates either in clockwise or in anticlockwise direction. At  $t = 0$ ,  $t = T/4$ ,  $t = T/2$  and  $t = 3T/4$  current distribution is studied along



**Fig. 5** Surface current density distribution at 3.1 GHz **a**  $t = 0$ , **b**  $t = T/4$ , **c**  $t = T/2$ , **d**  $t = 3T/4$

with their sense of rotation in the azimuthal plane with  $+z$  axis being considered as the direction of propagation. A clockwise rotation shows LHCP nature while anti-clockwise rotation depicting RHCP nature. From the plotted current distribution at various time instants in Fig. 5, we observe that current vector follows anti-clockwise rotation with  $+z$  axis being considered as the direction of propagation which results in RHCP nature of polarization. So the direction of rotation of current vector along with axial ratio less than 3 dB confirms circular polarized behavior of antenna for a frequency range 2.33–3.90 GHz. Axial ratio in the upper band is quite high and also the current vector just oscillates about its position between  $0$  and  $180^\circ$  thereby confirming the linear polarized behavior in the upper band.

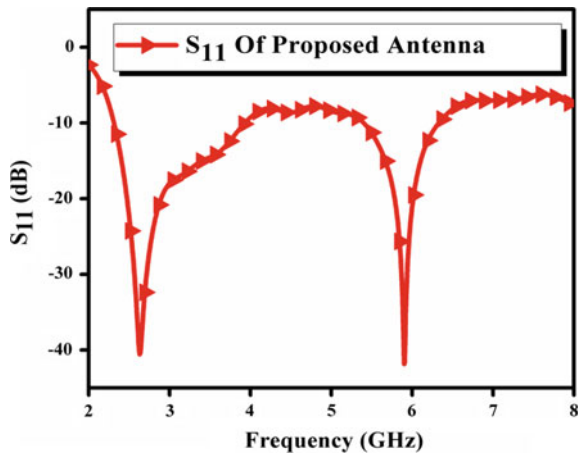
### 4 Result and Discussion

The proposed antenna is designed and simulated on CST Microwave Studio. The simulated farfield parameters of the proposed antenna are optimized for acceptable values. Figure 6 shows the simulated  $S_{11}$  (dB) of the proposed antenna which remains below  $-10$  dB for a frequency range extending from 2.3 to 3.90 GHz and 5.4–6.3 GHz.

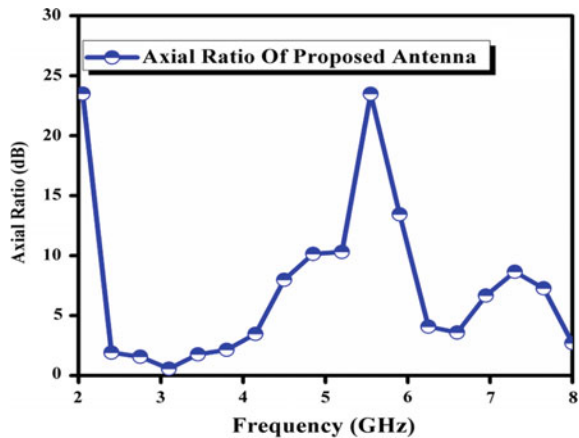
The overlapping frequency for lower resonating band resides between 2.33 and 3.90 GHz, i.e.,  $S_{11} < -10$  dB and axial ratio less than 3 dB. Hence, the circular polarized nature of the proposed antenna is observed for this overlapping frequency band (Fig. 7).

Maximum achievable gain of the proposed antenna is 4.27 dBi and is depicted in Fig. 8. Normalized LHCP and RHCP radiation pattern of the proposed antenna at

**Fig. 6** Simulated  $S_{11}$ -parameter of proposed antenna



**Fig. 7** Simulated axial ratio of proposed antenna



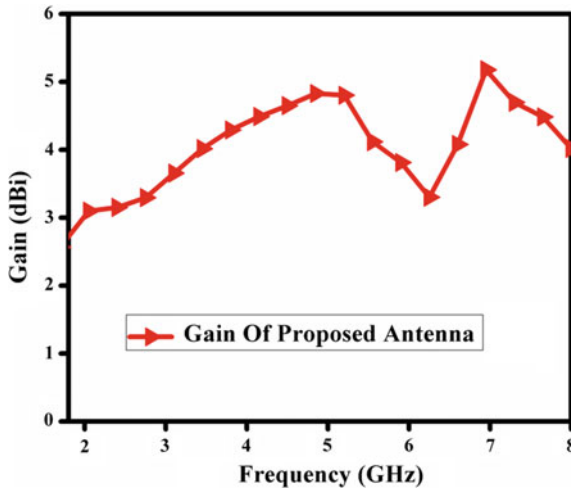


Fig. 8 Gain of proposed antenna

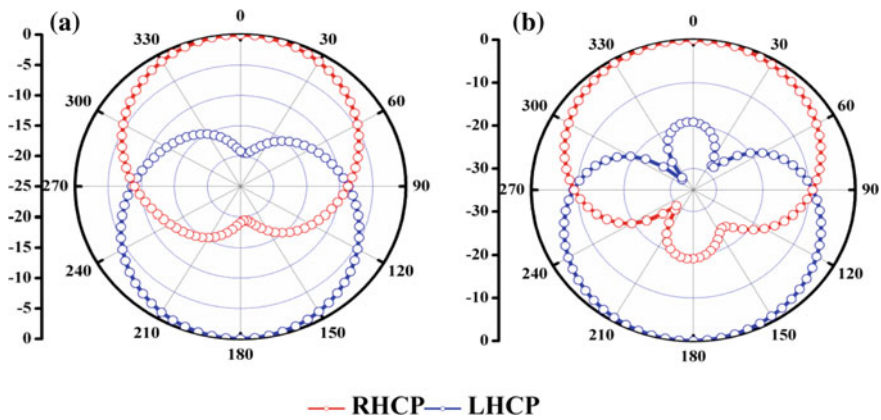


Fig. 9 Normalized LHCP and RHCP radiation patterns of proposed antenna **a** at 3.1 GHz at  $xz$ -plane, **b** at 3.1 GHz at  $yz$ -plane

3.1 GHz in both XZ and YZ plane with considering +z direction as the boresight of antenna is shown in Fig. 9 which confirms the RHCP nature of the antenna. The lower resonating band is circularly polarized while the upper band is linearly polarized with both bands resonating at two different frequency. The basic challenge in designing of the proposed antenna was that the impedance bandwidth must entirely enclose the axial ratio bandwidth which means axial ratio must be less than 3 dB for resonant frequencies for which  $S_{11}$  is less than  $-10$  dB which is called as overlap bandwidth.



## 5 Conclusion

A dual band dual polarized planar slot antenna is presented in this paper using coplanar waveguide feed technique. The proposed antenna consists of circular slot in the ground plane and an asymmetric radiating patch directly connected to the feed acting as a primary radiator. Numbers of rectangular conducting slits are embedded in the ground plane and are perturbed into the circular slot to achieve circular polarized characteristics. A circular notch is created in the radiating patch to introduce dual polarization characteristics. The proposed antenna has a quite simplified geometry with same antenna exhibiting both linear polarized and circular polarized characteristics for different resonating bands and it covers Bluetooth and WLAN band. The proposed antenna is a dual band antenna with lower band is right-handed circularly polarized and the upper band is linear polarized.

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