

# Circular polarized multi band dual sense square slot antenna fed by coplanar waveguide

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**Abstract:** A Circular polarized multi band dual sense coplanar waveguide (CPW)-fed square slot antenna is designed for wireless communication applications. The designed antenna consists of two parasitic patches. Within the proposed design structure, by varying the sizes of patches, good impedance matching can be achieved. In this antenna there are two Impedance bandwidths (IBWs) ranges from 2.65-5.43 GHz and 5.77-6.19 GHz and they are two Axial ratio bandwidths (ARBW) ranges from (2.88-3.00) GHz and (4.98-5.35)GHz within the IBW. The dual impedance band designed antenna is meant to operate at resonant frequencies of 4.04GHz & 5.98 GHz. It generates a dual circular polarized band that operates at 2.94 GHz and 5.2GHz; they are Left Hand Circular Polarization (LHCP) and Right Hand Circular Polarization (RHCP). Low-cost FR4 epoxy is the substrate material used having a dielectric constant of 4.4( $\epsilon_r$ ). The antenna is designed using Ansoft HFSS software. The parameters like reflection coefficient, ARBW, gain, radiation pattern, and radiation efficiency have been simulated and analyzed. The proposed antenna lower ARBW band can be suitable for some S-band wireless communication and a higher ARBW band can be suitable for WLAN applications.

**Keywords:** Coplanar waveguide (CPW)-fed, Impedance Bandwidth (IBW), Axial Ratio Bandwidth(ARBW), Left Hand Circular Polarization(LHCP), Right Hand Circular Polarization(RHCP).

## 1. INTRODUCTION

The circularly polarized dual-band (DB), dual-sense (DS), and the broadband planar antenna has caught the interest of researchers in recent years due to the growing demand for increased capacity and multiple function capabilities in wireless communication systems. Wide-spread use of the planar antenna [1] in mobile and wireless communications because of its straightforward design and inexpensive price. In order to meet all the criteria of contemporary wireless communication systems, including the need for compact, lightweight portable devices and the ability to combat the effects of multipath fading, circularly polarized (CP) antennas have emerged as the most viable choice. Due to their unique circular polarization, CP antennas don't matter about how the transmitting or receiving antennas are lined up or pointed. This makes multipath fading less of a problem.[2]. This makes them very effective and suitable for wireless communication applications like satellite communication and broadcasting.

Dual-band antennas [2-8] with two simultaneously operating dual circular (DP) polarization (anticlockwise or RHCP and clockwise or LHCP) are currently considerably more prevalent than dual band antennas with two-phase difference (vertically/horizontally) linear polarizations. Using an antenna with multiband features that also satisfy dual polarization performance reduces the need for additional antennas.

Circular polarization antennas are very useful when compared to linear polarization antennas. There is lots of research going on dual band dual polarized dual sense (DBDPDS) antennas because they have both LHCP and RHCP. Inspired by some DBDPDS above references it is focused to design the project. This article proposes a signal line of two horizontal branches, two parasitic patches, and a dual-frequency dual-sense circularly polarized printed square slot antenna. The antenna is designed using a single feed and its etched on a single dielectric layer.

This study is divided into three sections: Section 2: Antenna Design Procedure; Section 3: Simulation Results and Discussion; and Section 4: finish with a conclusion.

## 2. ANTENNA DESIGN PROCEDURE

This section is based on the antenna design. The coplanar waveguide fed circular polarized square slot antenna of dual band dual sense having two patches for 3.00GHz and 5.2 GHz is designed.FR4 epoxy is the substrate substance used for designing this antenna. The dimensions of the proposed antenna are 70×70×1.6 mm<sup>3</sup>. It exhibits LHCP and RHCP, so it is a dual-sense antenna[9]. The patches presented in this antenna are not physically connected. When power is given to the antenna patches are activated due to the coupling of electromagnetic fields.To achieve impedance matching, a 0.7

mm space is left between the ground plane and the signal line. In this antenna there are two Impedance bandwidths ranges from 2.65-5.43 GHz and 5.77-6.19GHz and they are two Axial ratio bandwidth ranges from (2.88-3.00) GHz and (4.98-5.35)GHz.

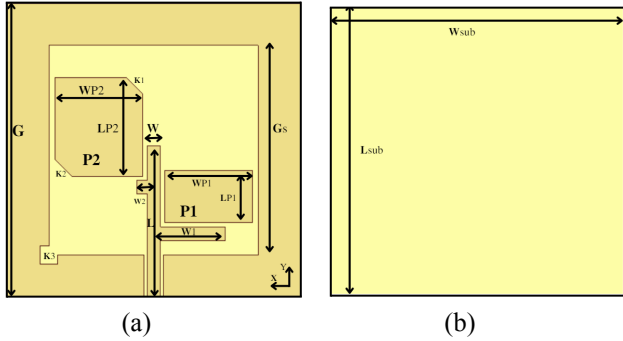


Fig. 1 Designed antenna dimensions (a) Top View, (b) Bottom View

TABLE- I

ANTENNA OPTIMAL DIMENSIONS HAVE BEEN IMPLEMENTED

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
G	70	L	36	Wp2	22	K1	4
Gs	50	W	3.2	Lp2	25.6	K2	4
Wp1	21	W1	15.5	Wsub	70	K3	3
Lp1	12.5	W2	2.5	Lsub	70	Hsub	1.6

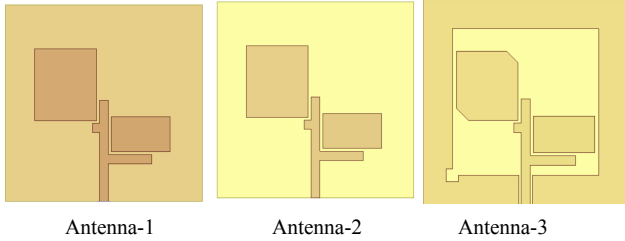
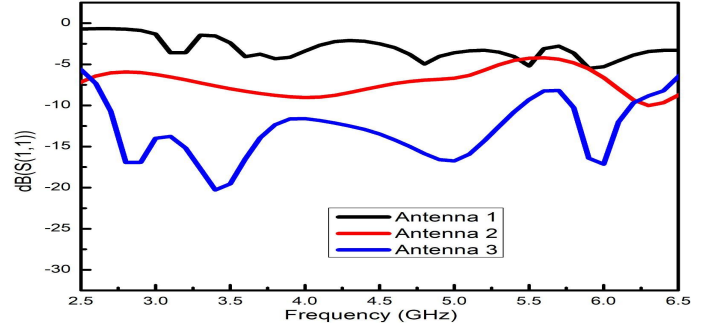


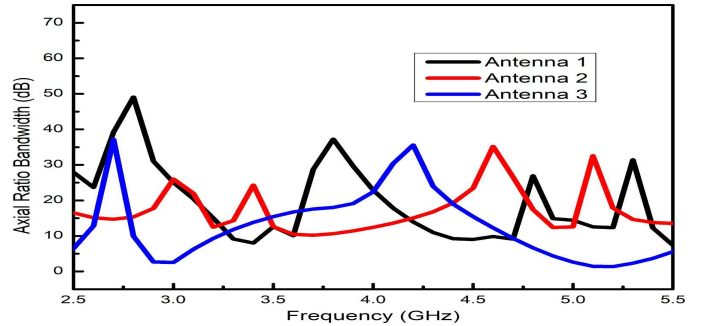
Fig-2 Three Improvement steps for Antenna's evolution

The step by step design procedure are added in Fig. 2. Antenna 1 is designed using a signal line of two horizontal branches, two parasitic patches with the full ground on the opposite side of the substrate. The low-cost FR4 epoxy material is used here as substrate material. But from Fig. 3 it can be seen the impedance bandwidth is very poor and it's given the resonance only at a higher resonating frequency region. So, in order to improve IBW at a lower resonating frequency, it need to be increase additional current path. That can be possible by using CPW-fed ground [7]. So, a CPW-fed ground plane is used, and designed Antenna 2. From Fig. 3(a) and (b) it can be seen that CPW-fed ground improve the IBW in lower as well as higher frequency region. One band resonating nearly 2GHz and another resonating at 8GHz. But the ARBW performance are very poor, so designed Antenna 3. In Antenna 3, to improve ARBW performance a small slot is etched on the left most bottom corner on the CPW-fed [9] ground. It improves horizontal current in x-direction and the CPW-fed ground increase the vertical current along y-direction. So, these two things together create a CP which is LHCP, at lower resonating frequency 3GHz. To improve

ARBW performance more in this step, the parasitic Patch P2 is truncated along the left diagonally. This P2 increase horizontal current along the x-direction at a higher resonating frequency of 5.2 GHz and the single line vertical patch increases the vertical current along y-direction. These two patches together create a CP at a higher resonating frequency 5.2GHz, which one is RHCP. Here Antenna 3 also give dual IBW, resonating at 4.04 GHz & 5.98 GHz. So, a single device together gives dual IBW and dual CP band within IB region which are dual sense [10] i.e. LHCP and RHCP. As this design satisfy the aim so it is considered as optimal design.



(c)



(d)

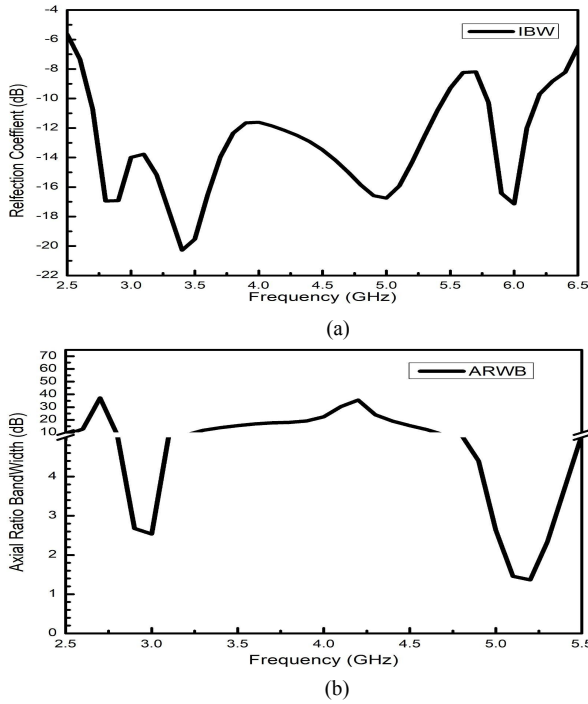
Fig. 3 Evaluations of three improvement processes for the proposed antenna (c) reflection coefficient, (d) axial ratio bandwidth.

### 3. RESULTS AND DISCUSSION

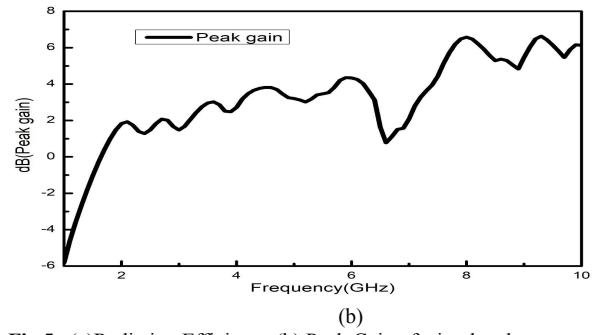
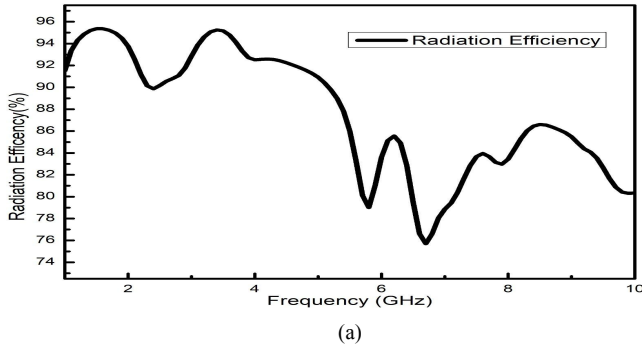
Using the simulation programme Ansys HFSS, the antenna is designed. The designed dual band dual sense antenna the dual stimulated IBW ranges from 2.65-5.43 GHz (2780 MHz,  $f_{rc1} = 4.04$  GHz, 63.63%) and 5.77-6.19 GHz (420 MHz,  $f_{rc2} = 5.98$ GHz, 7.02%) as described in the fig 4(a) .

Fig. 4(b) describes the ARBW of the designed antenna. The proposed antenna ARBW ranges from 2.88 -3.00 GHz (120 MHz,  $f_{cp1} = 2.94$  GHz, 4.08%) and 4.98 -5.35 GHz (370 MHz,  $f_{cp2} = 5.165$  GHz, 7.16%).

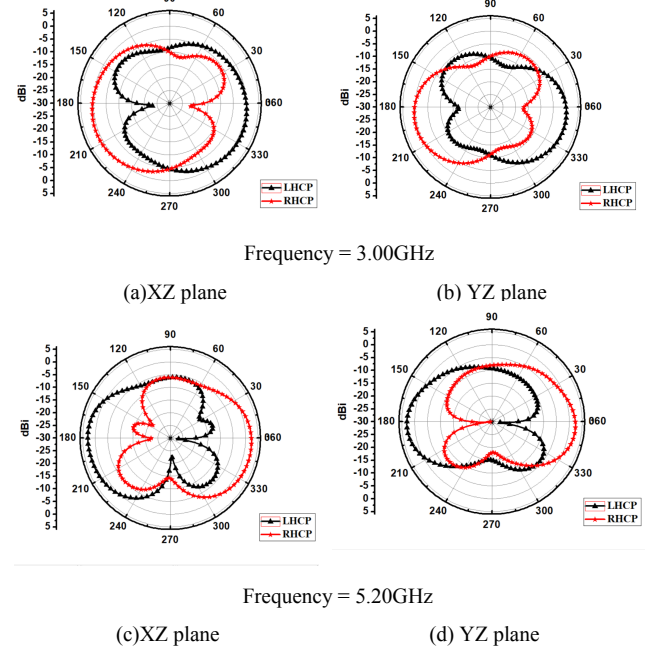
The lower resonating cp band(2.88GHz-3.00GHz) is useful for applications like Aeronautical radio navigation , Meteorological aids , Radio location , Maritime radio navigation . The higher resonating cp band (4.98GHz-5.35GHz) is useful for applications like Fixed mobile, Radio astronomy , Passive space research, Aeronautical radio navigation and radio location .



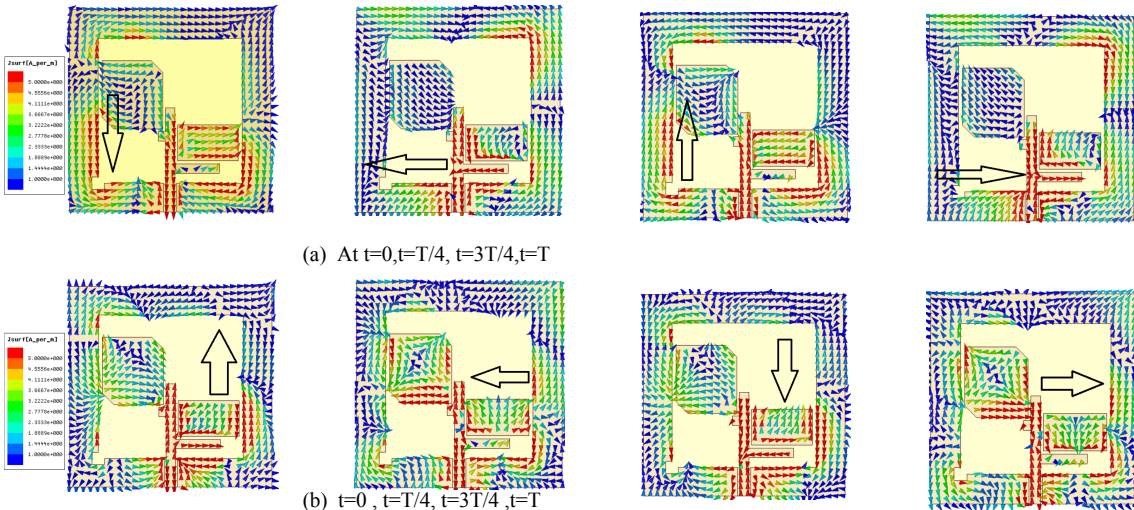
**Fig 4:** Simulated (a)IBW graph (b) ARWB graph for designed Antenna. From the stimulated radiation efficiency plot (Fig 5(a)) the efficiency ranges from (79%-95%). Peak radiation efficiency is 95 % at 3.4 GHz frequency. From Fig 5(b) we can observe that peak gain of the proposed antenna is 4.35 dB at 5.9 GHz frequency.



**Fig 5:** (a)Radiation Efficiency (b) Peak Gain of stimulated antenna. LHCP and RHCP radiations with polarization (co and cross) disparities of 17 dBi and 22 dBi, respectively, are the two CP resonating frequencies 3GHz and 5.2 GHz on which they were observed at broadside.



**Fig 6:** RHCP and LHCP Radiation patterns in (a), (c) at XZ ( $\phi=0^\circ$ ) and (b), (d) at YZ ( $\phi=90^\circ$ ) planes.



**Fig 7:** Generated current distribution at (a)  $f_{cp1}=3.00\text{GHz}$ , (b)  $f_{cp2}=5.20\text{ GHz}$

It is a quantitative observation Fig. 7 to help explain how the twin CP modes at 3.00 GHz and 5.2 GHz are generated. According to the normalized currents distribution shown in the following figures, two CP modes could be attained at  $f_{cp1}=3.00$  GHz and  $f_{cp2}=5.2$  GHz, which are LHCP and RHCP, respectively, for four separate time periods ( $t=0$ ,  $t=T/4$ ,  $t=3T/4$ , and  $t=T$ ), here T is the total time period for one cycle. A comparative study of proposed work and related other reference work has been demonstrated in Table 2 . From this comparison it can be concluded that proposed work gives reasonable good dual Impedance Bandwidth Dual Sense dual Circular Polarized Band Within IBW region.

**Table 2**

Comparative Analysis of the Proposed Antenna to Other Papers

Reference No	Size (mm <sup>2</sup> )	Frequency (GHz)	Polarization	S <sub>11</sub> BW%	AR BW%
Ref.[2]	70 x 70	1.576/4.248	LHCP/RHCP	26.2 / 55.23	4.88 / 3.01
Ref.[3]	70x70	1.74/2.82	LHCP/RHCP	62.85 / 77.40	57.09 / 3.24
Ref.[7]	70x70	1.6/2.2	LHCP/RHCP	8.7 / 23	8.4 / 19.24
proposed	70x70	3.0 / 5.2	LHCP/RHCP	63.63 / 7.02	4.08/7.16

#### 4. CONCLUSION

A new method for dual-band circular polarized antenna with dual sense fed by coplanar waveguide is proposed and implemented. Impedance bandwidth ranges from (2.65-5.43) GHz and (5.77-6.19) GHz. Axial ratio bandwidth ranges from (2.88-3.00)GHz and (4.98-5.35)GHz. It's give two axial ratio bands within impedance bands. In this design there are two parasitic patches. Second patch is trunked to increase ARBW. This antenna exhibits both LHCP and RHCP, so it has dual sense properties .

The proposed antenna design has lower resonating frequency at 3.00 GHz and higher resonating frequency at 5.2 GHz . At 3.00 GHz the LHCP polarization is greater than RHCP by an amount of 17dBi and at 5.2 GHz RHCP polarization is greater than LHCP by an amount of 22dBi. So dual sense property is exhibited successfully. Since it has a higher resonating frequency at 5.2 GHz which is very useful for most wireless applications. Peak gain of the antenna at lower resonating frequency is 1.47 dB and at higher resonating frequency is 3.01dB and peak gain of the antenna is 4.35 dB at 5.9 GHz frequency. Radiation efficiency of the antenna at lower resonating frequency is 92% and at higher resonating frequency is 89% and peak radiation efficiency is 95 % at 3.4 GHz frequency. The proposed antenna will be suitable for some S-band and WLAN applications.

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