

# Asymmetric CPW – FED ground plane with circularly polarized printed monopole antenna with SRR

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**Abstract:** This paper discusses a dual band asymmetric Coplanar Waveguide (CPW) – FED ground plane with Circularly Polarized (CP) printed monopole antenna with SRR. The proposed design consists of a rectangular patch which is excited using 50  $\Omega$  microstrip line feeding. The dimension of the antenna is 55×50×1 mm<sup>3</sup>. A semi hexagonal slot has been created at the left side of the ground plane so as to enhance the dual axial ratio bandwidth (ARBW). The proposed antenna achieves the dual simulated impedance bandwidth (IBW) of 1.74 – 1.86 GHz (0.12 GHz, 66.6%, resonating at 1.18 GHz) and 3.37 – 4.44 GHz (1.07 GHz, 28.16%, resonating at 3.9 GHz). The simulated dual ARBW achieved is over 1.75 – 1.86 GHz (0.11 GHz, 61.1%, resonating at 1.805 GHz) and 3.38 – 4.41 GHz (1.03 GHz, 26.44%, resonating at 3.9 GHz). The proposed design manifests the Left-Hand Circular Polarization (LHCP) radiation pattern. The lower CP band can be used for GSM1800 band and higher CP band can be used for 3.5 GHz for 5G application.

**Keywords:** Split Ring Resonator (SRR), Impedance Bandwidth (IBW), Circular Polarization (CP), Coplanar Waveguide (CPW), Axial Ratio Bandwidth (ARBW), Left-Hand Circular Polarization (LHCP)

## 1. INTRODUCTION

Multiple requirements of various devices are now met in wireless communication systems by using dual-band dual-polarized (DBDP) antennas. Circularly polarized (CP) antennas have recently received a lot of attention in a variety of communication systems such as GPS, RFID, WLAN, and WiMAX. The primary disadvantages of using linearly polarized waves to achieve dual band performance are lower sensitivity, multipath fading to the positioning of the Tx (transmitting) and Rx (receiving) antennas, and lower movability. When compared to linearly polarized antennas, circularly polarized antennas overcome multipath fading, improve system performance, and can provide better mobility with weather penetration. Printed monopole antennas have been studied in recent years due to their advantages of low profile, low cost, broadband operating bandwidths, and simple structure. Dual band antennas [1-4] with two quadrature (vertically/horizontally) linear polarisations (anticlockwise or right hand circular polarization (RHCP) and clockwise or left hand circular polarization (LHCP)) [5-6] are now significantly more common than dual band antennas [7-10] with two quadrature (vertically/horizontally) linear polarisations. The use of an antenna with multiband characteristics that also meets dual polarization performance reduces the need for multiple antennas.

A dual band with an asymmetric Coplanar Waveguide (CPW) – FED ground plane with Circularly Polarized (CP) printed

monopole antenna with SRR has been proposed in this paper inspired by the above mentioned antenna characteristics. The proposed antenna supports dual simulated impedance bandwidth of 1.74 – 1.86 GHz and 3.37 – 4.44 GHz. The design has been sufficiently enhanced to produce both circular polarisations.

## 2. Procedure for the antenna design

The simulated dual band CPW antenna design is demonstrated in Fig.1. The antenna is built using FR4 substrate which has a dimension of 55×50×1 mm<sup>3</sup>, loss tangent ( $\tan\delta$ ) of 0.02 and a dielectric constant ( $\epsilon_r$ ) of 4.4. The proposed design consists of a rectangular patch which is excited using 50  $\Omega$  microstrip line feeding. The optimized design parameters have been demonstrated in the Table - 1. The antenna's implementation progress stages have been demonstrated in Fig.2. The designed antenna's return loss and ARBW progress graphs have been demonstrated in Figures 3(a) and (b).

At first a Coplanar waveguide - fed monopole Antenna 1 is proposed which creates a primary resonant mode at 2.4 GHz having the monopole's quarter-wavelength. In this case, because of small horizontal components, the horizontal current is canceled out. As a result, it is linearly polarized, and the AR value across the entire band is excessively high. So, in Antenna 2 an asymmetric ground plane and asymmetric monopole feeding are used to generate a horizontal component. But we observe that the generated ARBW does

not meet the 3 dB criteria, hence Antenna 3 is designed to improve the ARBW's performance. In Antenna 3 a square-ring [5] is allotted at the left part of the rectangular monopole. Also a semi hexagonal slot is constructed at the left side of the ground plane. plane. The right most asymmetric CPW- FED ground plane creates vertical current and SRR creates horizontal current at lower resonating frequency 1.8 GHz. This together creates a CP at this lower resonating frequency, whereas the rightmost asymmetric CPW-FED ground creates horizontal current and left most semi hexagonal notches CPW fed ground creates vertical current at higher resonating frequency 3.9 GHz. This together creates CP at this resonating frequency which is 3.9 GHz. As a result, dual band with additional dual CP is achieved, resulting in LHCP at both lower and higher resonating frequencies.

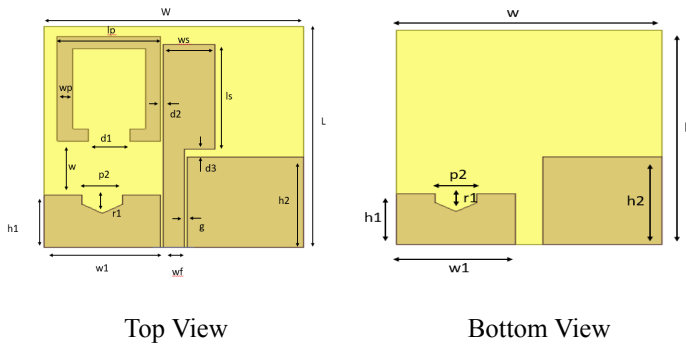


Fig. 1 Proposed antenna geometry

TABLE- I

ANTENNA OPTIMAL DIMENSIONS HAVE BEEN IMPLEMENTED

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
d1	8	ws	10	h1	13	lp	20
d2	0.5	wp	3	h2	24	L	55
d3	0.5	h	1	W	50	ls	30.5
wf	4	w1	23	g	0.35	w	1.35
		r1	4.5	p2	13.8		

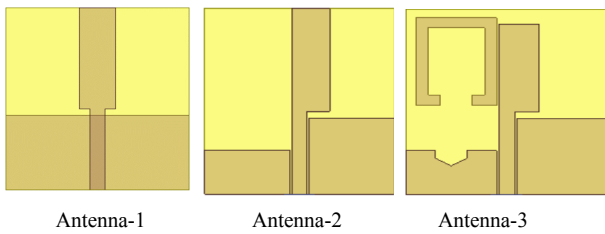
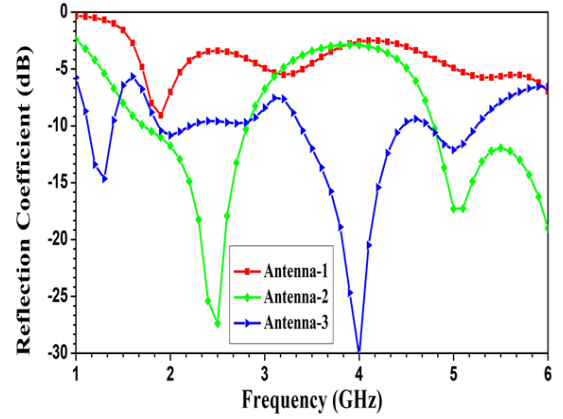
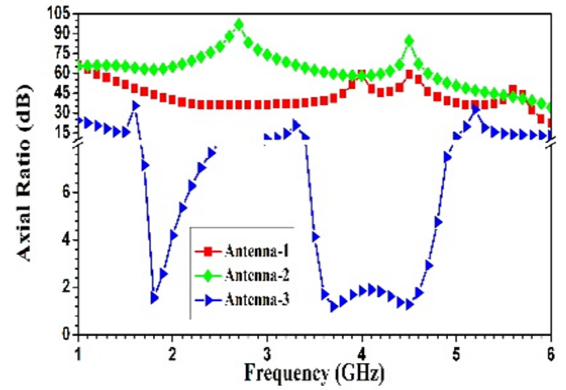


Fig-2 Different stages of Antenna design



(a)

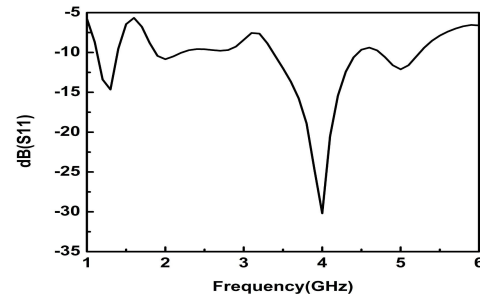


(b)

Fig. 3 Comparison of (a) S11 and (b) ARBW for different stages of antenna (1-3)

### 3. RESULTS AND DISCUSSION

The design for the proposed antenna has been created using Ansys High Frequency Structure Simulator (HFSS). The proposed antenna achieves the dual IBW of 1.74 – 1.86 GHz (0.12 GHz, 66.6%, resonating at 1.18 GHz) and 3.37 – 4.44 GHz (1.07 GHz, 28.16%, resonating at 3.9 GHz) which has been demonstrated in Fig.4(a). The dual ARBW achieved is over 1.75 – 1.86 GHz (0.11 GHz, 61.1%, resonating at 1.805 GHz) and 3.38 – 4.41 GHz (1.03 GHz, 26.44%, resonating at 3.9 GHz) which has been demonstrated in Fig.4(b).



(a)

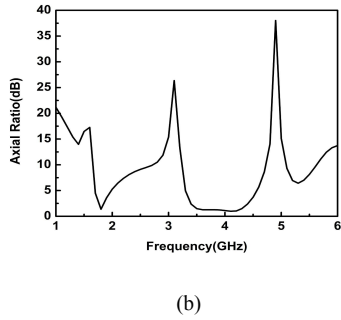


Fig 4: (a) S11 and (b) ARBW of the proposed Antenna

Fig.5 demonstrates a smith chart [6] in which the graph rotates two times which proves that by using this antenna a dual impedance bands are generated.

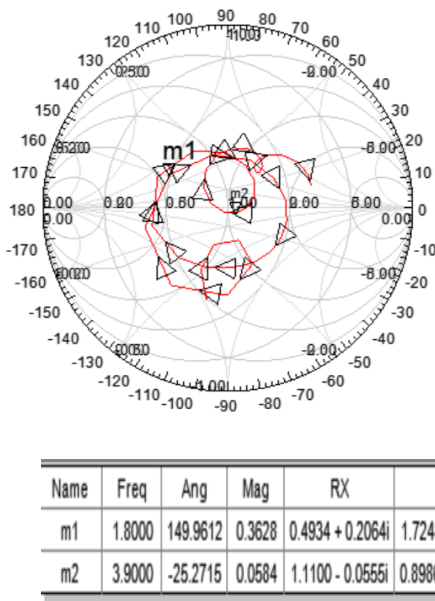


Fig 5: Smith Chart for the proposed antenna

Fig.6 (a) demonstrates the peak gain versus frequency. The peak gain at 1.8 GHz is 1.46 dbi, 3.9 GHz is 2.16 dbi and 4.2 GHz is 4.14 dbi. Fig.6(b) demonstrates the radiation versus frequency. The antenna's simulation-derived maximum radiation efficiency is from 93.2% to 98.7% where for 1.8 GHz is 93.2%, for 4.11 GHz is 97.1% and for 5.4 GHz is 98.7%.

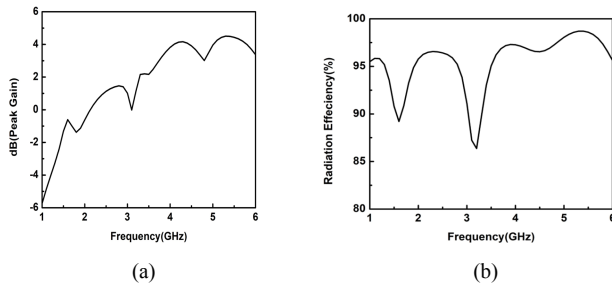


Fig 6: Simulated Antenna (a) Peak Gain Vs Frequency (b) Radiation Efficiency Vs Frequency

Fig.7(a), (c) demonstrates LHCP and RHCP radiation patterns at  $\phi = 0^\circ$  and (b), (d)  $\phi = 90^\circ$ , which are shown at  $f_{cp1} = 1.8$  GHz and  $f_{cp2} = 3.9$  GHz. At those resonating frequencies, polarization is LHCP because LHCP is greater than RHCP by an amount of 20dbi and 23dbi respectively.

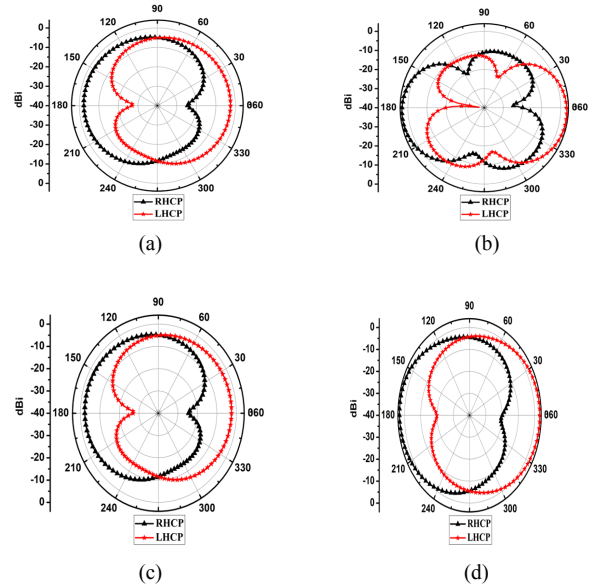
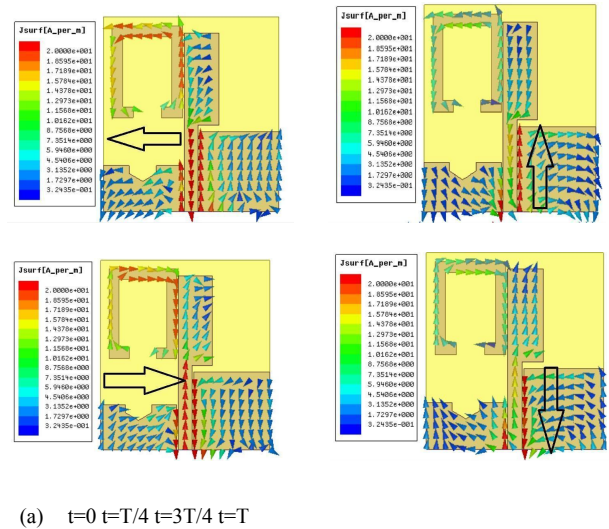
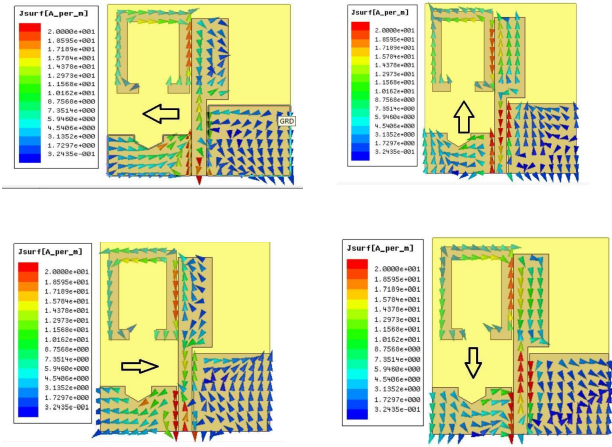


Fig 7: Radiation pattern (LHCP and RHCP) for (a), (c)  $\phi = 0^\circ$  and (b), (d)  $\phi = 90^\circ$

Fig.8 shows the stimulated current distribution at 1.8 GHz and 3.9 GHz which explains how the dual CP modes are generated. From the figure given below we can observe that at different time moments that is  $t=0$ ,  $t=T/4$ ,  $t=3T/4$ ,  $t=T$  where  $T$  is the total period of time for one cycle, dual CP modes obtained at  $f_{cp1}=1.8$  GHz and  $f_{cp2}=3.9$  GHz are both LHCP.



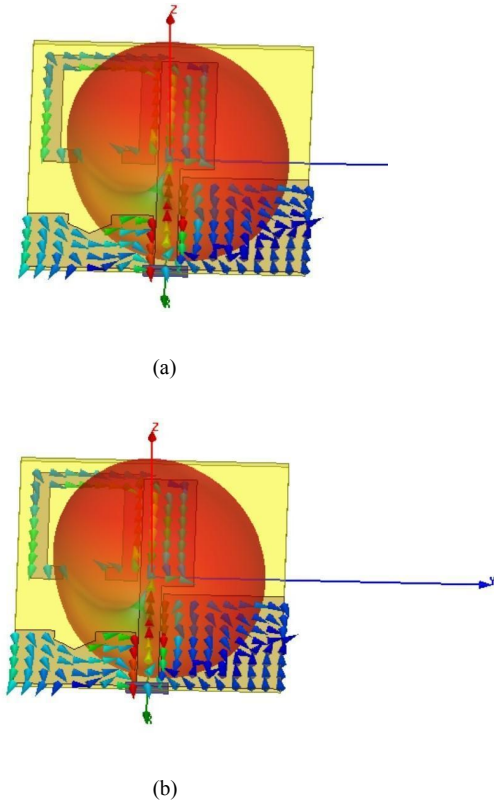
(a)  $t=0$   $t=T/4$   $t=3T/4$   $t=T$



(b)  $t=0$   $t=T/4$   $t=3T/4$   $t=T$

**Fig 8:** Current distribution at (a)  $f_{cp1}=1.8$  GHz, (b)  $f_{cp2}=3.9$  GHz

Fig.9(a) and 9(b) show the total 3D directivity patterns at  $f_{cp1}=1.8$  GHz and  $f_{cp2}=3.9$  GHz, used to find the antenna's radiation patterns. Fig. 9(a) - (b) show that circular polarization is obtained as y direction and x direction currents have nearly the same amplitude and  $90^\circ$  phase.



**Fig 9:** Proposed antenna's total 3D directivity patterns at(a)  $f_{cp1} = 1.8$  GHz, (b)  $f_{cp2}=3.9$  GHz

Table 2 compares the proposed work with associated other DBDP antennas. From table 2 it can be concluded that the proposed work gives good reasonable ARBW which is within the IBW region.

**Table 2:** Comparison of different DBDP antennas

Reference	Year of Publication	IBW(MHz)	ARBW(MHz)	Size ( $mm^2$ )
[1]	2019	240/ 2730	260/ 2480	43×49
[2]	2019	48/ 150	50/ 170	50×50
[3]	2020	90/ 270	62/ 93	77×103
[4]	2021	224/ 420	130/ 770	70×70
Proposed	2022	120/ 1070	110/ 1030	55×50

#### 4. CONCLUSION

A dual band asymmetric Coplanar Waveguide (CPW) – FED ground plane with Circularly Polarized printed monopole antenna with SRR is proposed. The optimized dimension of the proposed antenna is  $55 \times 50 \times 1$  mm<sup>3</sup>. The proposed antenna achieves dual IBW, which is 66.6% at lower frequency and 28.16% at higher frequency region. The simulated dual ARBW's achieved at lower frequency band is 61.1% and at higher frequency region is 26.44%. The lower CP band can be utilized for GSM1800 band and the higher CP band can be utilized for 3.5 GHz for 5G application.

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