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Design & Analysis of Triband Circularly Polarised Annular Slot Antenna

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Abstract*: A single feed tri band circularly polarised annular slot antenna is simulated in this paper. The antenna structure is composed of two non-concentric slots that are fed by an L-shaped series step impedance micro strip feed line configuration. The proposed antenna is designed to operate at the 1.25GHz, 1.61GHz and 2.27GHz frequencies. The return loss for corresponding frequencies are -23.81dB, -21.025dB & -19. 85dB.The gain at the respective frequencies are Simulated results show good return losses, VSWR, & axial ratio are obtained owing to this design, HFSS software is used to design and simulate the antenna.

***Keywords*: Circular polarization; Slot antenna; Tri band antenna;**

I. INTRODUCTION

Circularly polarized (CP) antennas have received much attention for the applications of the wireless communication services such as global and positioning system (GPS) and other wireless communication systems. It is well known that circular polarization for antennas can reduce the propagation loss caused by multipath effects between the transmitter and receiver antenna. Thus, the circularly polarized antenna has been found very useful for wireless communication systems such as GPS [1-3]. Multi-band working pattern has become prevail to single-band mode. So it is greatly necessary to design a kind antenna to realize multi-band circular polarization and high gain at low elevation angle[4-6]. Various triple-band antennas for the wireless local area network (WLAN) and/or worldwide interoperability for microwave access (WiMAX) applications have been presented[7-11] However, some of these antennas did not achieve CP characteristics [7,8] or achieved them only for some of the three bands .

The wireless communication systems have two different operating bands, such as L1/L2 bands of GPS and 2.4/5.2 GHz of WLAN. Consequently, a CP antenna with dual-band operation is required. So far as planar resonant antennas are concerned, a considerable number of studies have been made on the dual-band CP design in the last few decades. These reported designs can be mainly divided into three types: stacking two resonant elements [12]-[14], using dual coplanar resonant elements [15]-[17], and embedding slots/slits into a single radiating patch [18]-[20]

In this paper the antenna consists of two non concentric annular slots with an L-shaped series step impedance feed configuration. The frequency-ratio of antenna can be controlled by adjusting the dimensions of two annular slots. This design is compact in structure and is suitable for L band frequencies. The performance of various antennas are compared and tabulated below.

Ref .No	Feed Type	Frequency	Return Losses	Axial Ratio
1	micro strip	2.21GHz 3.67GHz 4.5GHz	-20.25dB -14.5dB -25.15dB	1.11dB 1.52dB 157dB
2	L-shaped micro strip	2.55GHz 4.35GHz 5.57GHz	-27.5dB -22.89dB -11.63dB	1.25dB 1.24dB 1.11dB
3	L-shaped micro strip feed	1.2GHz 1.65GHz 2.45GHz	-16dB -16.5dB -22.5dB	1.05dB 1.5dB 1dB

Table 1: Comparison of reference antennas

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II. PROPOSED ANTENNA DESIGN & CONFIGUARATION

The structure of the desired antenna is shown below. In this antenna design two non concentric annular slots and an L-shaped step impedance micro strip feed line is placed opposite sides of the microwave RO4003 substrate with r = 3.38, tanδ = 0.0027, and thickness h = 0.813 mm. The centre line of the horizontal L-shaped feed line and the centre line of the vertical L-shaped feed line are intersected at the origin O. Origin O, O_1, (centre of the outer slot ring) and O_2 (centre of the inner slot ring) string on the same line having a angle of 45° with x-axis. To simplify the design, the width w_f of the feed line was chosen to be 1.7 mm.

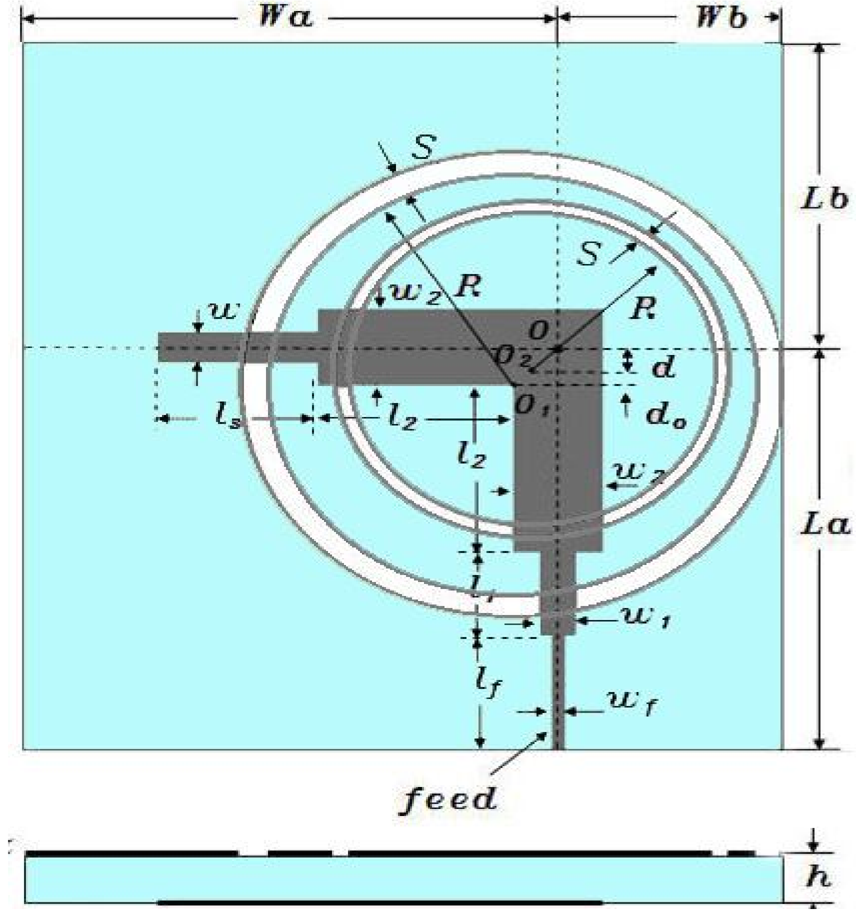

Fig 1: Design of the proposed Antenna

The corresponding characteristic impedance is 50Ω. The length l_f of the feed line was chosen to be 15mm.In order to investigate the mechanism of the tri-band CP antenna, the current distributions for the three frequencies simulated by HFSS are shown in Fig 2.

The resonant frequency for low frequency is mainly determined by the circumference of the outside annular slot. Given by the following equation, which is about one guided wavelength at the low frequency

$$1= (2 * \pi * (R1 + S1/2))$$

R1- Radius of the outer annular slot
S1- Thickness of the outer annular slot
The middle resonant frequency is mainly determined by the circumference

$$C2=(2 * \pi * (R2 + S2/2))$$

R2- Radius of the inner annular slot
S2- Thickness of the inner annular slot
of the inner annular slot, which is about one guided wavelength at the middle frequency.

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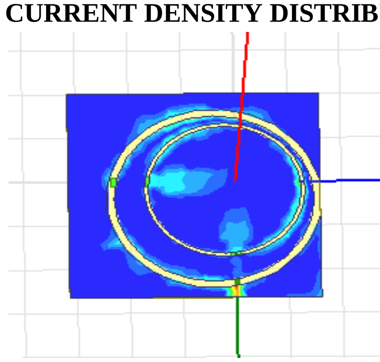
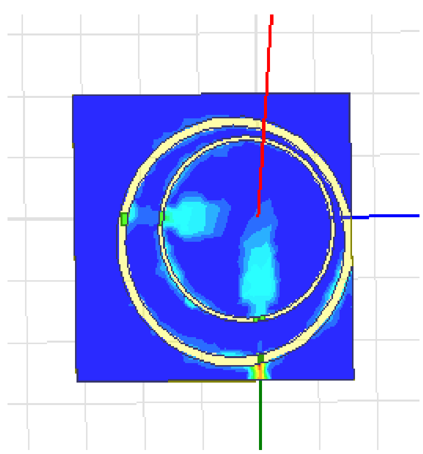
Parameters	Dimensions (mm)
Wa	60
W_b	35
W_f	1.7
w_1	4
w_2	10
h_1	0.813
R_1	40.79
R_2	30.49
d	5
Parameters	Dimensions (mm)
L_a	53
L_b	40
l_f	15
l_1	11
l_2	22
l_s	18
S_1	3
S_2	1.5
d_o	3

Table 2: Dimensions of proposed antenna

III. CURRENT DENSITY DISTRIBUTIONS





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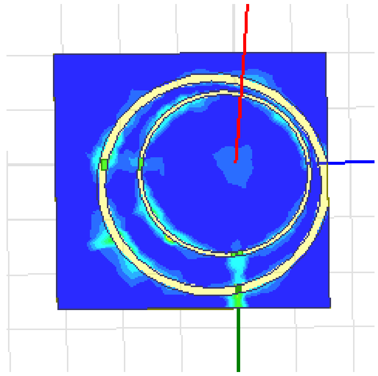

(a) (b) (c)

Fig 2: Surface current distributions for the three bands. (A) Lower frequency, (B) Middle frequency, and (C) Upper frequency

Length of the feed line chosen to be 15mm and radius R_1&R_2 were chosen be 40.66mm and 30.36 mm for L1&L5 bands respectively. The optimized values of S_1&S_2 were 3&3 and W_1&W_2 were 4&10 respectively. The optimized parameter values of the proposed antenna were given in table 1. An L shaped series step impudence feed line is etched to improve the parameters of the proposed antenna in L1&L5 bands.

IV. PARAMETERS STUDY

In this parameter results of the antenna at different origin positions are demonstrated. And the resulting values of the antenna parameters like return losses , VSWR , Axial ratio at variable operating frequencies are shown in below Tables.

A. CASE 1:

Parameters Fc=1.37GHz, R1=38.21mm,R2=29mm , S1=3mm, S2=1.5mm , h=0.813mm

Origin	**Frequency**	**Axial Ratio**	**Return Losses**	**VSWR**
O1=(5,-5,0.813) O2=(3,-3,0.813)	1.138GHz 1.58GHz 1.80GHz	7.50dB 1.14dB 2.67dB	-12.54dB -24.40dB -23.67dB	1.57 2.63 2.83
O1=(6,-6,0.813) O2=(3,3,0.813)	1.27GHz 1.55GHz 1.80GHz	4.23dB 4.6dB 2.3dB	-16.23dB -14.69dB -18.13dB	2.54 1.83 1.05
O1=(6,-6,0.813) O2=(4,-4,0.813)	1.52GHz 1.80GHz 2.33GHz	3.9dB 3.9dB 4.9dB	-13.31dB -15.10dB -25.85dB	1.24 1.86 1.22

Table 3:Parameter responses at different origins

B. Case 2:

Parameters : Fc=1.40GHz, R1=40.79mm, R2=30.49mm, S1=3mm, S2=1.5mm, h=0.813mm

Origin	Frequency	Axial Ratio	Return Losses	VSWR
O1=(8,-8,0.813) O2=(4,-4,0.813)	1.25GHz 1.47GHz 1.62GHz	1.25dB 1.47dB 1.62dB	-23.88dB -17.93dB -18.27dB	1.5 1.19 1.23

Table 4: Response with the effective radius 40.79mm,30.49mm

C. Case : 3

Parameters: Fc=1.39GHz, R1=40.79mm, R2=30.49mm, S1=3mm, S2=1.5mm, h=0.813mm

Origin	Frequency	Axial Ratio	Return Losses	Vswr
O1=(7,-7,0.813)	1.3056GHz	3.64dB	-31.15dB	1.05
O2=(4,-4,0.813)	1.6667GHz	3.18dB	-19.996dB	1.28
	2.3333GHz	4.14dB	-18.95dB	1.25
O1=(7,-7,0.813)	1.305GHz	2.8dB	-29.44dB	1.06
O2=(5,-5,0.813)	1.635GHz	5.6dB	-22.91dB	1.3
	2.278GHz	3.32dB	-20.21dB	2.19

Table 5: Response with the effective radius 40.79mm,30.49mm at different origins

D. Final case

Parameter : Fc=1.39GHz, R1=40.79mm, R2=30.49mm, S1=3mm, S2=1.5mm, h=0.813mm

Origin	Frequency	Axial Ratio	Return Losses	Vswr
O1=(8,-8,0.813)	1.25GHz	1.9dB	-23.81dB	1.13
O2=(4,-4,0.813)	1.611GHz	0.33dB	-21.05dB	1.26
	2.27GHz	2.14dB	-19.73dB	1.23

Table 6: Response at final case

The Simulated antenna is designed from the final case parameters using on a Rogers RO4003 laminate. Figure 3 illustrates the AR plotted against frequency. Figure 4 illustrates the simulated S11 parameters. Figure 5 illustrates the VSWR plot.

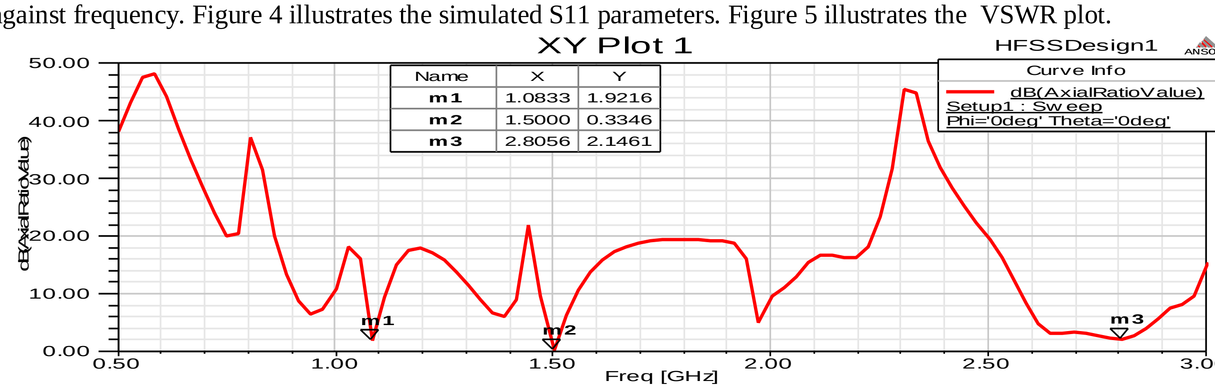

fig 3: Axial Ratio

The axial ratios are 1.9dB for 1.08GHz , 0.3dB for 1.5GHz and 2.14dB for 2.5GHz for lower band middle band, and upper band.

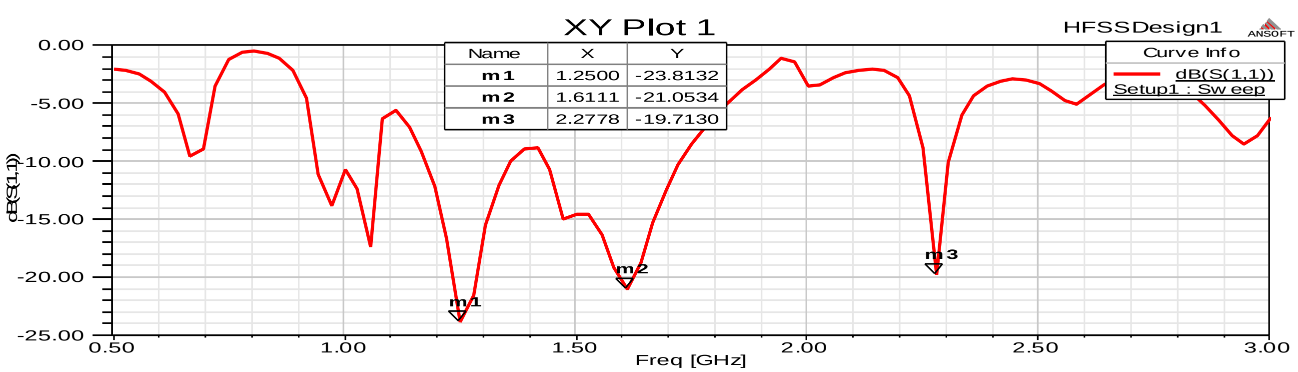

Fig 4: Simulated Return losses

The above figure 4 shows the simulated return losses.The return losses are -23.8132dB for 1.25GHz, -21.05dB for 1.611GHz, and -19.71dB for 2.27GHz.

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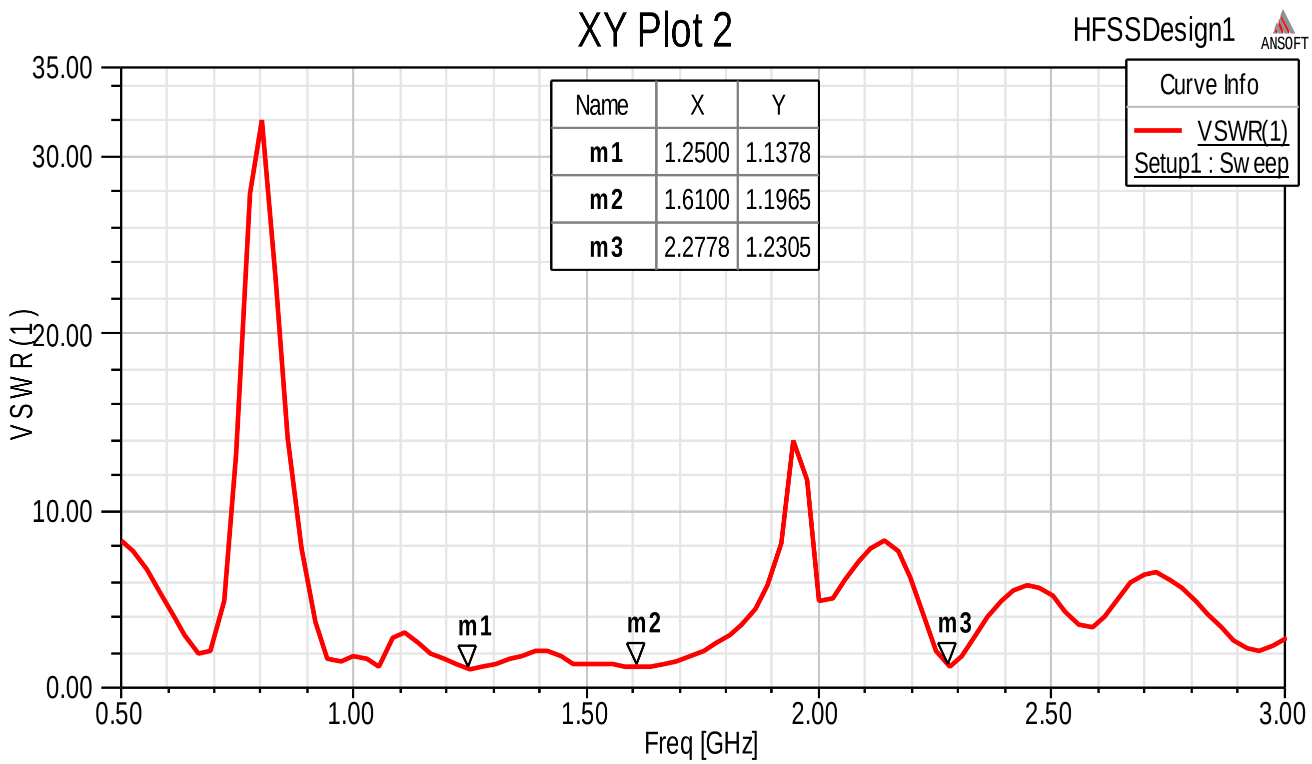
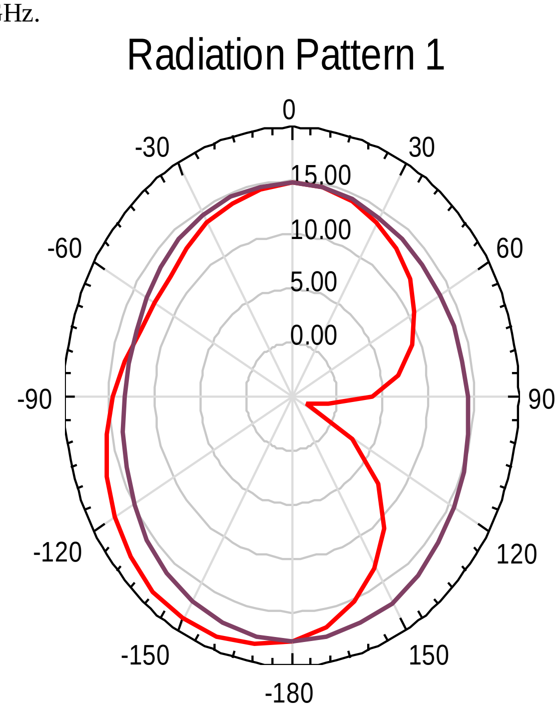
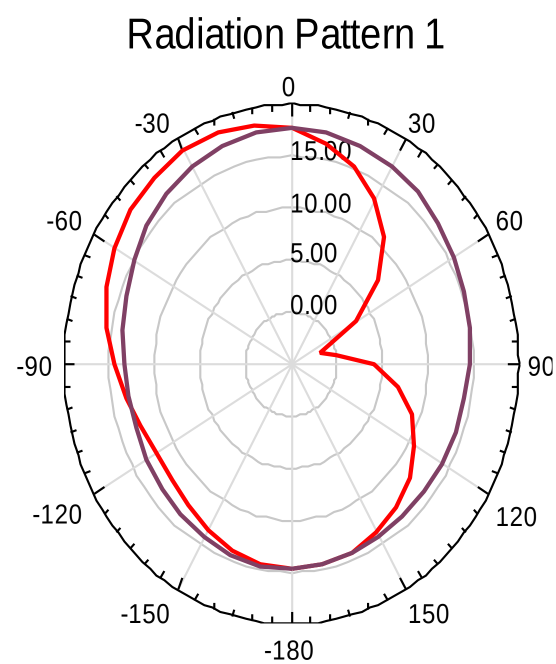


Fig 5: Simulated VSWR

The above figure 5 shows the simulated VSWR. The simulated VSWR are 1.13 for 1.25GHz , 1.26 for 1.63GHz and 1.23 for 2.27GHz.



A) Radiation Pattern- LHCP



B) Radiation Pattern –RHCP

Fig 6 : Radiation patterns at 1.25 GHz. (a) XoZ-plane, (b) YoZ-plane.

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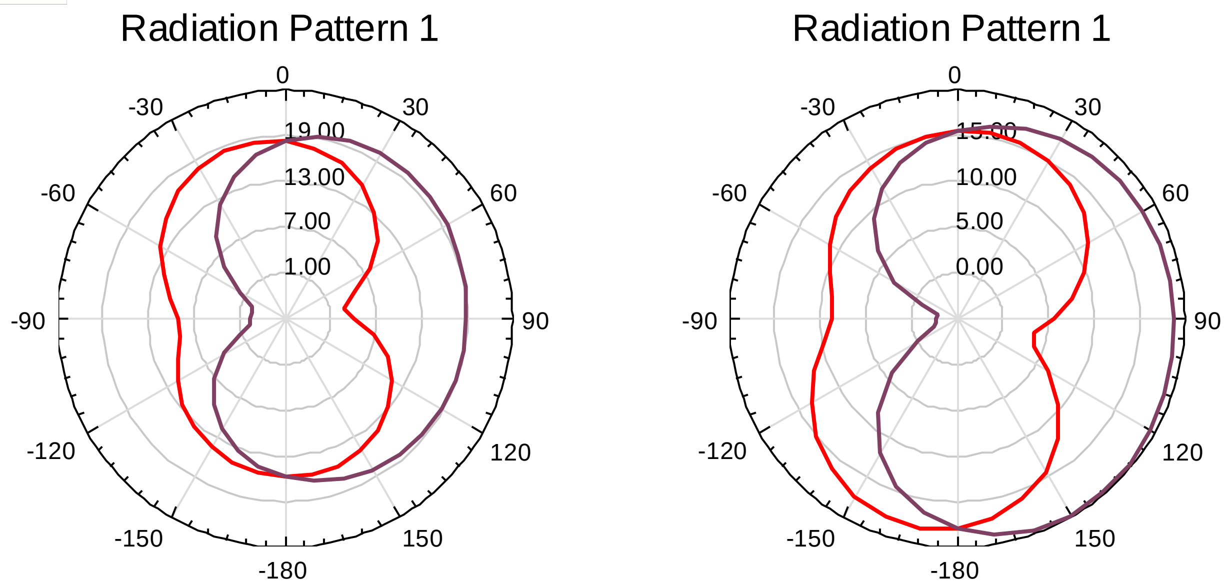
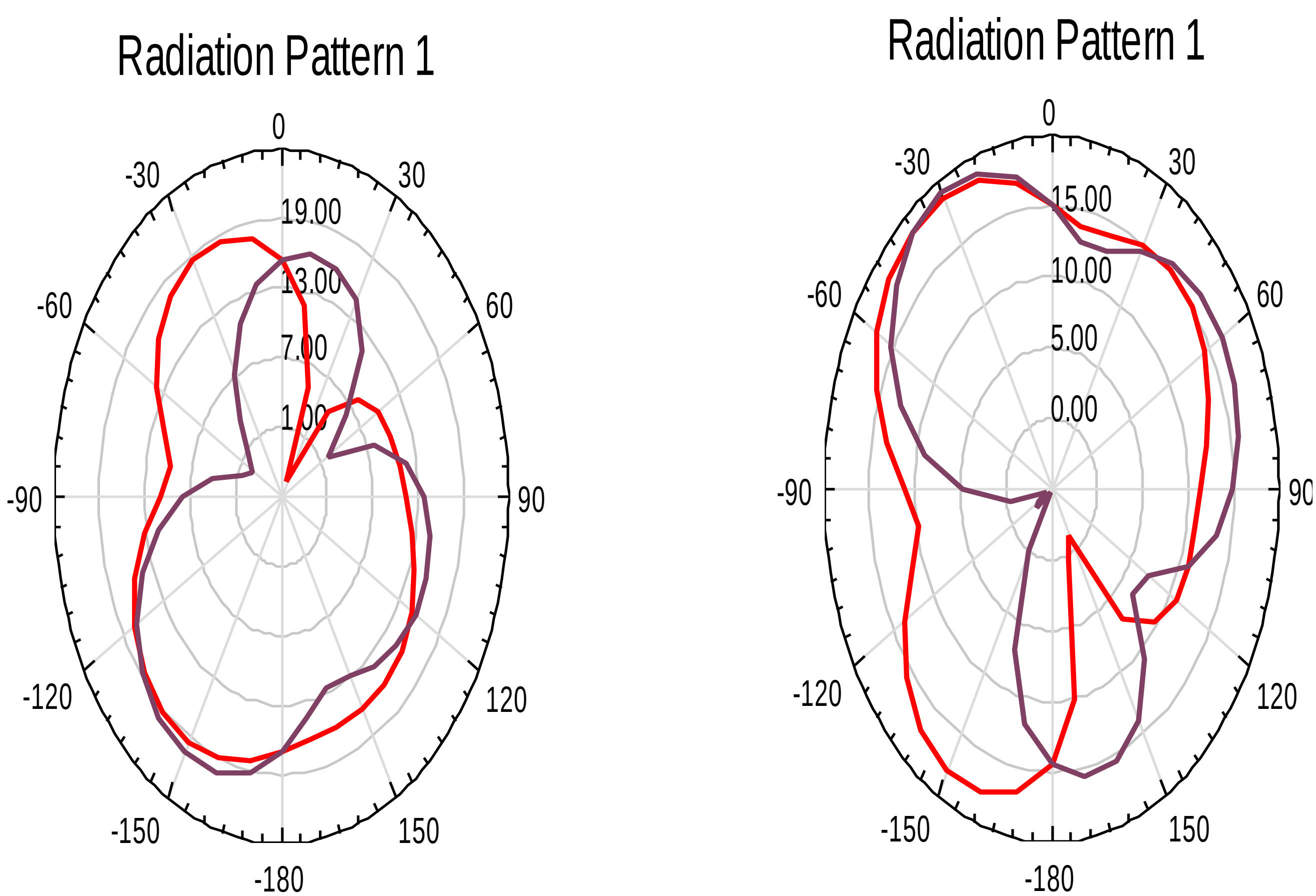


A) Radiation Pattern -LHCP B) Radiation Pattern RHCP

Fig 7 : Radiation patterns at 1.61 GHz. (a) XoZ-plane, (b) YoZ-plane.



A) Radiation Pattern- LHCP B) Radiation Pattern RHCP

Fig 8 : Radiation patterns at 2.27 GHz. (a) XoZ-plane, (b) YoZ-plane.

The radiation patterns at different frequencies are pltted in the figures 6,7and 8.

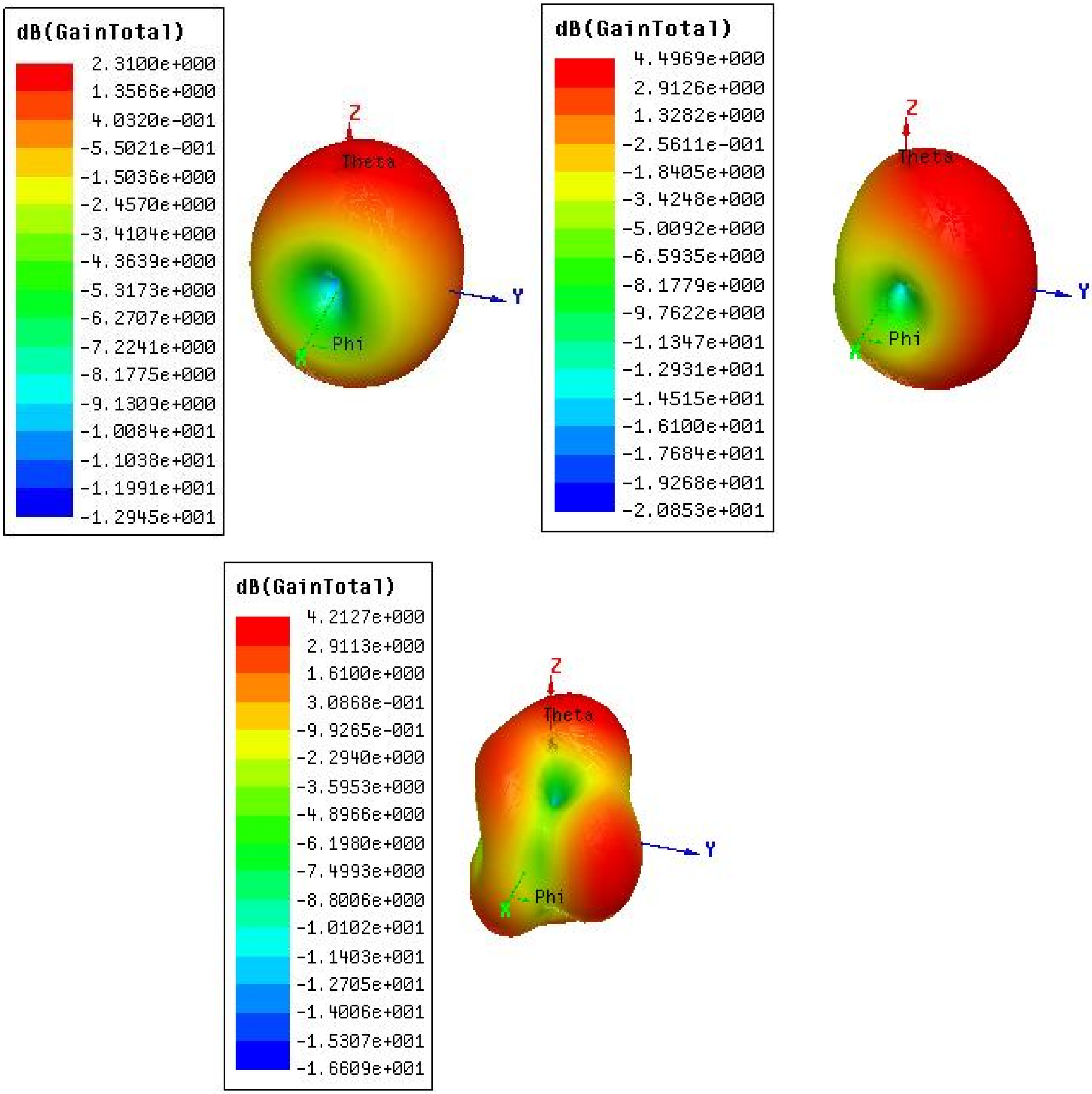


Fig 9: Simulated Gains

The above figure 5 shows the simulated Gains. The simulated Gains are 2.31dB for 1.25GHz , 4.49dB for 1.63GHz and 4.21dB for 2.27GHz.

V. CONCLUSION

A tri-band circularly polarized annular slot antenna is designed using a strip feed has been proposed. By employing two non concentric slots coupled with an L-shaped series step impedance feed line, a tri-band circular polarization was achieved at 1.25GHz, 1.61GHz and 2.27GHz. More parameters tuning freedom is achieved by using the series step impedance micro strip feed line. The simulated results obtained for Return losses, VSWR and Axial ratio are good when compared with that of the reference work.

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VI. ACKNOWLEDGMENT

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BIOGRAPHIES

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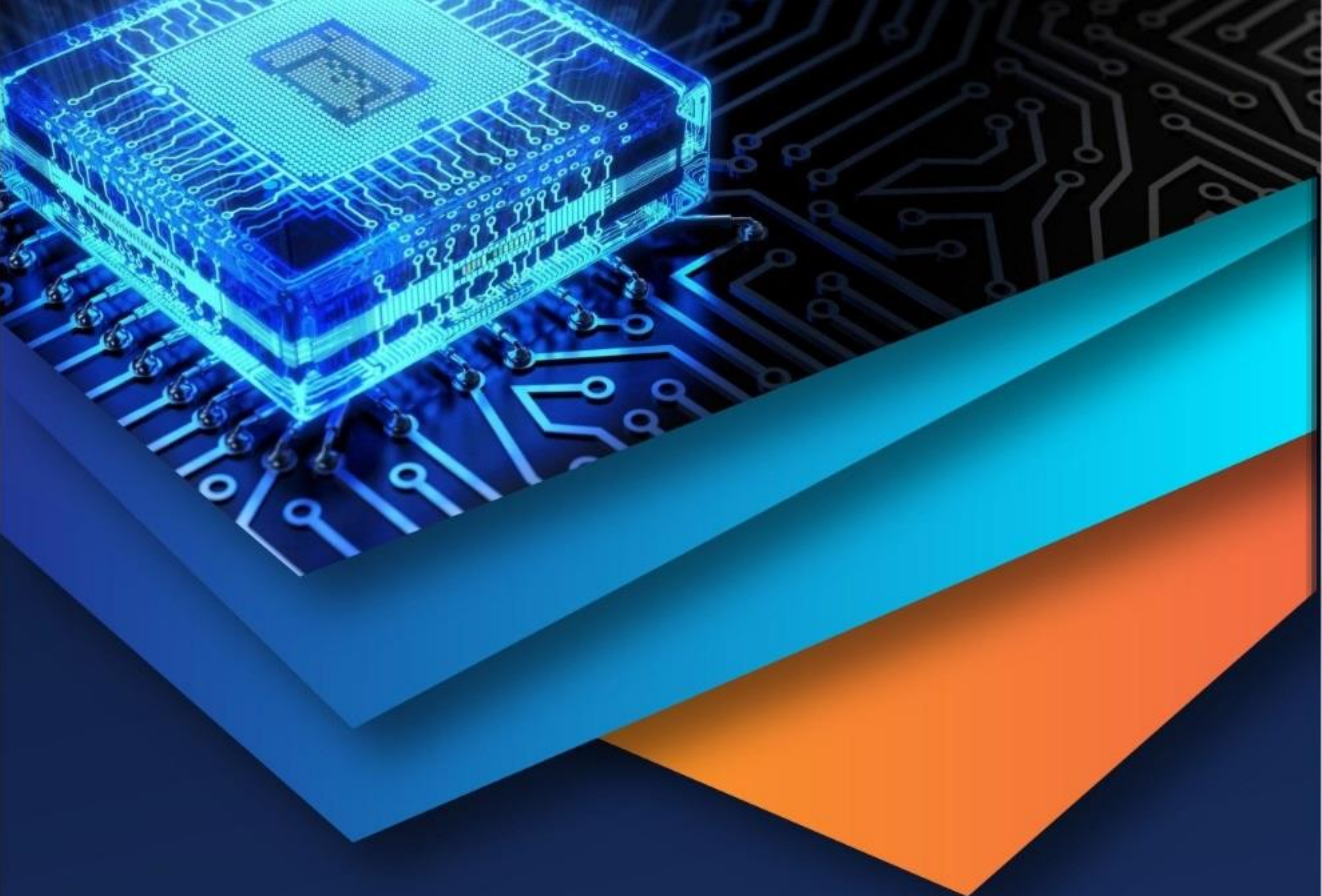

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