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# DESIGN & ANALYSIS OF TRI-BAND NON CONCENTRIC CIRCULARLY POLARIZED ANNULAR SLOT ANTENNA

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## ABSTRACT

In today's modern communication industry, antennas are the most important components required to create communication link. Multiple Frequency antenna is an antenna which works at multiple frequencies in which one part of antenna is active for one particular band of frequency. An L- shaped single feed multi-band circular polarized slot antenna is simulated in this project. The analysis and design of antenna structure is poised with two non concentric circular slots which are fed by a step impedance feed line. The proposed antenna is designed to operate at multiple bands in multiple frequencies. The output parameters like return loss, gain, axial ratio, and VSWR are measured for the corresponding frequencies. The simulation of this antenna structure is carried out by using HFSS software

**KEYWORDS**: Circular polarization; Slot antenna; Tri-band antenna.

## I. INTRODUCTION

In the field of wireless communication services such as GPS and various communication systems, circular polarized antennas are consider for their applications. In order the lower the propagation loss which are generated by multipath effects between transmitter and receiver antennas, circularly polarized antennas are usually required. Hence wireless communication systems use circular polarized antenna for their purpose. Multiband working pattern has been modified to single band mode. Hence it requires an antenna to be designed which features multiband circular polarization and high gain at low elevation angle. For WLAN under WiMAX applications many triple band antennas are available. The proposed antenna is designed to operate in L-band frequency i.e., L1 and L2 which is a circular polarized dual band antenna with acceptable gain and return losses.

## II. PROPOSED ANTENNA DESIGN & CONFIGUARATION

The construction of the designed antenna is described below. In this design the antenna has two non concentric angular slots and L-shaped step impedance microstrip feed line which is placed on the opposite sides of microwave RO4003 substrate with r = 3.38, tan□ = 0.0027 and thickness h = 0.813 mm. The centre lines of both horizontal L-shaped feed line and vertical L-shaped feed line are intersected at a point called origin O. Origin O, $O_1$ ( centre of the outer slotted ring ) and $O_2$ ( centre of the inner slotted ) string on the same line inclines at an a angle of $45^0$ with x-axis. In order to simplify the design, the width $W_f$ of the feed line selected as 1.7 mm.

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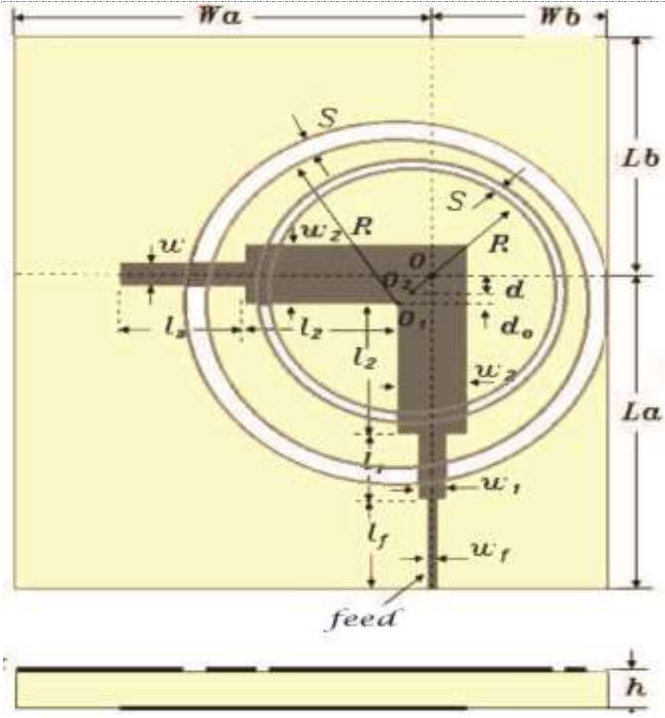


***Fig 1: Design of proposed antenna***

The corresponding characteristic impedance is 50Ω. The length of the feed line ($l_f$) was selected as 15mm. In order to examine the mechanism of the tri-band circular polarized antenna, the current distribution of the 3 frequencies as simulated by using HFSS as shown in fig 2. The resonant frequency for low frequency is mainly obtain by the circumference of outside annular slot.

From the equation which relates to one guided wavelength at low frequency.

$$\mathbf{C_1 = (2\pi\ (R_1 + S_1/1))}$$

$R_1$- Radius of the outer annular slot
$S_1$- Thickness of the outer annular slot

The middle resonant frequency is mainly determined by the circumference

$$\mathbf{C_2 = (2\pi\ (R_2 + S_2/2))}$$

$R_2$- Radius of the inner annular slot
$S_2$- 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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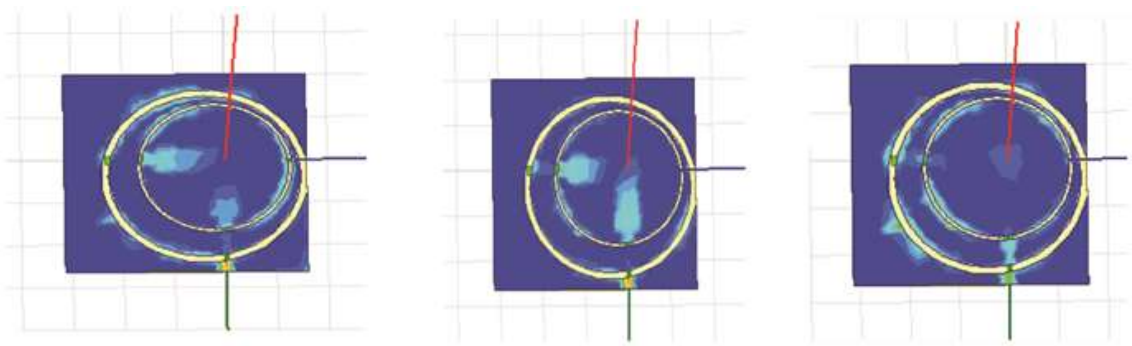
***Table 1: Dimensions of proposed antenna***

| Parameters | Dimensions (mm) |
|---|---|
| Wa | 60 |
| Wb | 35 |
| $W_f$ | 1.7 |
| $w_1$ | 4 |
| $w_2$ | 10 |
| $h_1$ | 0.813 |
| R1 | 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 |

## III. CURRENT DENSITY DISTRIBUTIONS



(a) (b) (c)

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

The length of the feed line, radius $R_1$ and $R_2$ were selected as 15 mm, 4.66 mm and 30.36 mm for L1 and L5 bands respectively. The improved values of $S_1$ and $S_2$ are 3, 3 and $W_1$ and $W_2$ are 4 , 10 respectively. The improved parameter values of the proposed antenna were given in table1. An L-shaped series step impedance feed line is defined to enhance the parameters of the proposed in L1 and L5 bands.

## IV. PARAMETERS STUDY

In this criteria, the results of the antenna at different origin positions are validated and resulting values of antenna parameters like return losses, VSWR, axial ratio at variable operating frequencies are described below.

**Model 1 :** Parameter responses at different origins

The parameters are $F_c$ = 1.37GHz, $R_1$ = 38.21mm, $R_2$ = 29 mm, $S_1$ =3mm, $S_2$ =1.5mm, h = 0.813mm.

For this operating frequency of 1.138GHz, considering origin at O1 (5,-5,0.813 ) , the resulted axial ratio , return loss and VSWR are 7.50dB, -12.54dB and 1.57 respectively and for operating frequency of 1.58GHz, considering origin at O2 (3,-3,0.813 ) , the resulted axial ratio , return loss and VSWR are 1.14dB, -24.40dB and 2.63 respectively

For this operating frequency of 1.27GHz, considering origin at O1 (6,-6, 0.813 ) , the resulted axial ratio , return loss and VSWR are 4.23dB, -16.23dB and 2.54 respectively and for operating frequency of 1.55GHz, considering origin at O2 (3,-3,0.813 ) , the resulted axial ratio , return loss and VSWR are 4.6dB,-14.69dB and 1.83 respectively.

For this operating frequency of 1.52GHz, considering origin at O1 (6,-6,0.813 ) , the resulted axial ratio , return loss and VSWR are 3.9dB, -13.31dB and 1.24 respectively and for operating frequency of 1.80GHz, considering origin at O2 (4,-4,0.813 ) , the resulted axial ratio , return loss and VSWR are 3.9dB, -15.10dB and 1.86 respectively.

**Model 2 :** Response with the effective radius 40.79mm,30.49mm

The parameters are $F_c$ = 1.40GHz, $R_1$ = 40.79mm, $R_2$ = 30.49 mm, $S_1$ =3mm, $S_2$ =1.5mm, h = 0.813mm.
For this operating frequency of 1.25GHz, considering origin at O1 (8,-8,0.813 ) , the resulted axial ratio , return loss and VSWR are 1.25dB, -23.88dB and 1.5 respectively and for operating frequency of 1.47GHz, considering origin at O2 (4,-4,0.813 ) , the resulted axial ratio , return loss and VSWR are 1.47dB, -17.93dB and 1.19 respectively.

**Model 3 :** Response with the effective radius 40.79mm,30.49mm at different origins

The parameters are $F_c$ = 1.39GHz, $R_1$ = 40.79mm, $R_2$ = 30.49 mm, $S_1$ =3mm, $S_2$ =1.5mm, h = 0.813mm.
For this operating frequency of 1.3056GHz, considering origin at O1 (7,-7,0.813 ) , the resulted axial ratio , return loss and VSWR are 3.64dB, -31.15dB and 1.05 respectively and for operating frequency of 1.6667GHz, considering origin at O2 (4,-4,0.813 ) , the resulted axial ratio , return loss and VSWR are 3.18dB, -19.996dB and 1.28 respectively

For this operating frequency of 1.305GHz, considering origin at O1 (7,-7 0.813 ) , the resulted axial ratio , return loss and VSWR are 2.8dB, -29.44dB and 1.06 respectively and for operating frequency of 1.635GHz, considering origin at O2 (5,-5,0.813 ) , the resulted axial ratio , return loss and VSWR are 5.6dB,-22.91dB and 1.3 respectively.

**Final model :** Response at final model

The parameters are $F_c$ = 1.39GHz, $R_1$ = 40.79mm, $R_2$ = 30.49 mm, $S_1$ =3mm, $S_2$ =1.5mm, h = 0.813mm.
For this operating frequency of 1.25GHz, considering origin at O1 (8,-8,0.813 ) , the resulted axial ratio , return loss and VSWR are 1.9dB, -23.81dB and 1.13 respectively and for operating frequency of 1.611GHz, considering origin at O2 (4,-4,0.813 ) , the resulted axial ratio , return loss and VSWR are 0.33dB, -21.05dB and 1.26 respectively.

The Simulated antenna is designed from the final case parameters using 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.

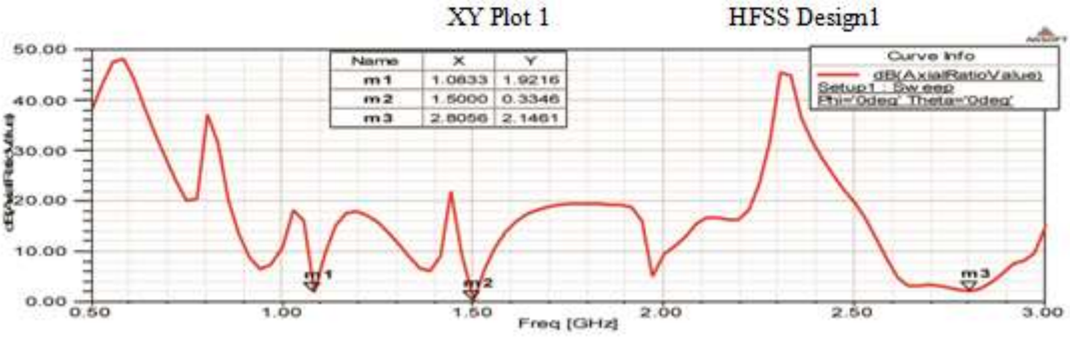



***Fig 3 : Axial ratio***

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.

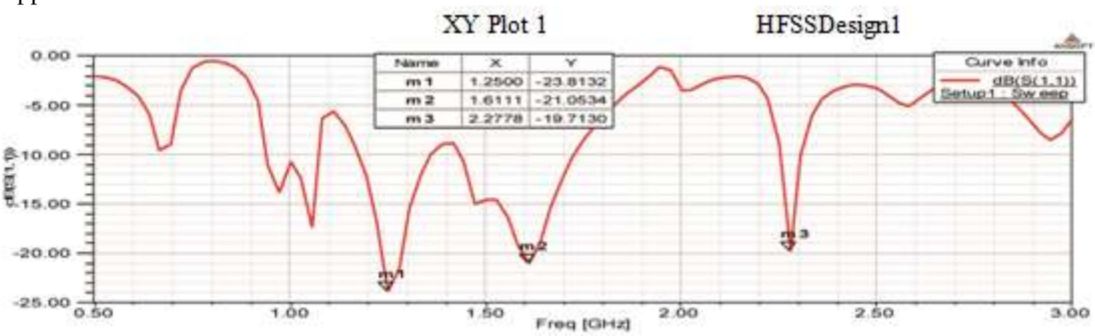



***Fig 4 : Simulated Return losses***

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.

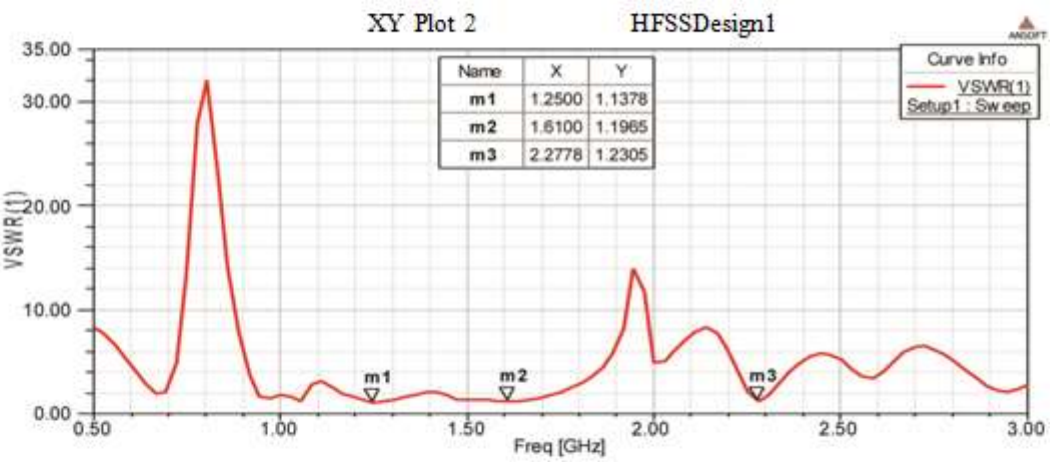



***Fig 5: Simulated VSWR***

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.

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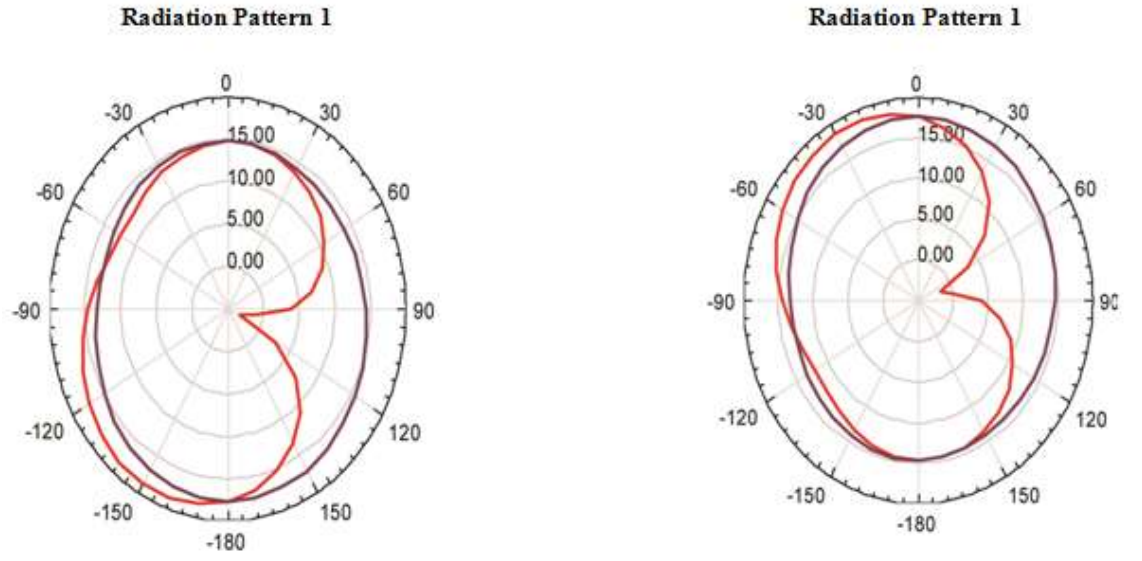
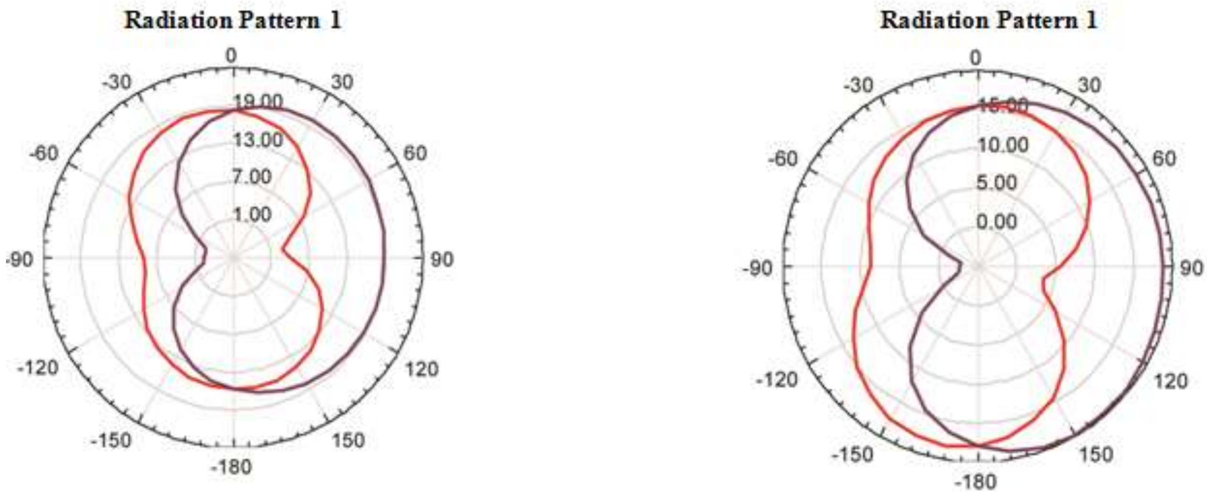



*A) Radiation Pattern- LHCP* *B) Radiation Pattern –RHCP*

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




*A) Radiation Pattern –LHCP* *B) Radiation Pattern RHCP*

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

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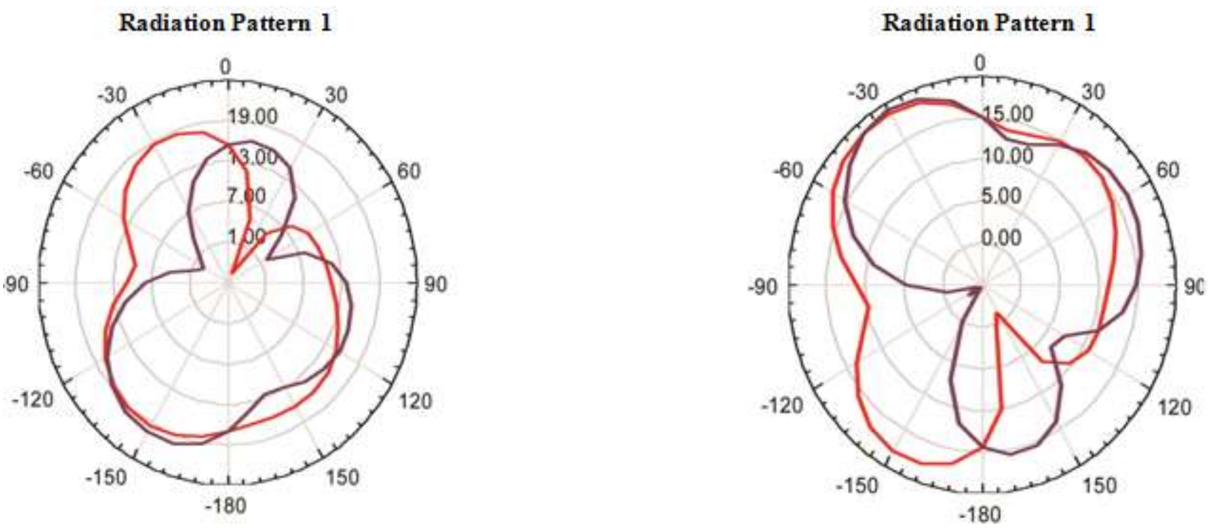


*A) Radiation Pattern- LHCP* *B) Radiation Pattern RHCP*

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

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

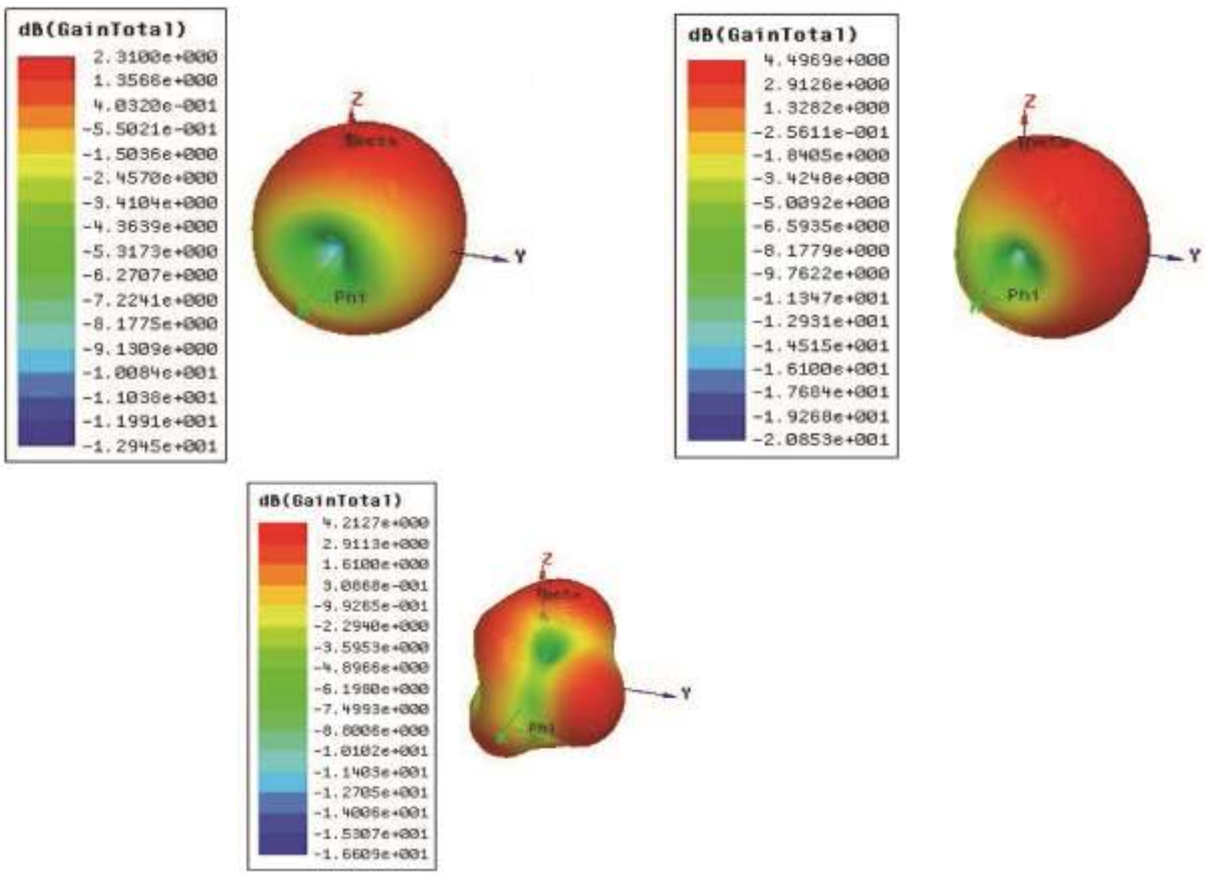


***Fig 9: Simulated Gains***

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

The proposed tri-band circularly polarized annular slot antenna has been designed by using a strip feed . With the help of two non concentric slots coupled with an L-shaped series step impedance feed line, a tri-band circular polarization is 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. By comparing with that of the reference work the obtained simulated results for Return losses, VSWR and Axial ratio are better.

## VI. ACKNOWLEDGEMENTS

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