

Asymmetric CPW-Feed Circularly Polarized Planar Slot Antenna With Changed Inverted L-Shaped Signal Line And Circular Ring Formed Grounded Strips

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Abstract

A novel style is delineated for a circular polarized planar slot antenna. Circular polarization operations is earned exploitation associate degree uneven feeding co-planner conductor. The axial ratio bandwidth can be significantly enhanced by implanting a pair of circular shaped grounded strips at diagonally opposite corners of the rectangular slot. By adjusting the dimensions of the modified inverted L-shaped signal line with circular shaped strip and radius of the circular shaped grounded strips, the circular polarized bandwidth can be achieved as high as 40%. The measured results of this antenna has return loss bandwidth 56% from frequency 2.12GHz to 3.76GHz at VSWR ≤ 2 throughout this band and axial ratio band width 40% from frequency 2.2GHz-3.29GHz at AR ≤ 3 dB.

Keywords- Axial ratio (AR), Circular polarization, Broadband, Rectangle slot antenna, CPW-feed.

I. INTRODUCTION

Due to flexible orientation between transmitter and receiver, the circular polarization antennas are commonly used in Global Positioning Systems (GPS) & Satellite Communication [1]-[10]. For putting in a transmitter and a receiver while not polarization couple between them, circular polarization (CP) is changing into helpful in communications to extend system performance and providing higher quality in inclemency condition than linearly polarization [11]-[13]. The effect of multipath reflection and other interferences can be significantly reduced with the help of circularly polarized antennas. Planar antennas with different types of feeding lines (cpw, microstrip, and strip) have been found as suitable to fulfil circular polarization applications [14]- [15]. Planar slot antennas with wide radiating slot provides bidirectional radiation patterns, simultaneous RHCP and LHCP and have been used in satellite digital radio systems and for reception of terrestrial signals [16]- [17]. Therefore, coplanar waveguide fed circular polarized planar antenna have drawn a great deal of attraction recently. For generating circular polarization radiation using one feed, many microstrip antenna designs are reported flat conductor CPW-fed sq. slots are utilised within the designing of the various broadband circularly polarised planar antennas In recent years, varied shapes and designs of broadband CP slot antennas are developed to beat the narrow impedance and axial-ratio bandwidths (ARBWs) [18]-[19].

A broadband circularly polarized slot antenna is presented in this paper. The projected antenna has changed inverted L-shaped feed line beside a combine of circular arc formed grounded strips at diagonally opposite corners of the slot. The pair of circular arc shaped grounded strips and asymmetric CPW feed line generate two orthogonal resonant modes. The inverted L shaped signal line is used as a feed line. A circular arc shaped strip is also embedded on the modified inverted L-shaped signal line to avoid mismatch at the lower cut-off frequency of the impedance and axial ratio bandwidth.

II. ANTENNA DESIGN AND ANALYSIS

FR4 substrate is employed for planning purpose that has relative permittivity 4.4 and loss tangent 0.02. The volume of the antenna is $60 \times 50 \times 1.6 \text{mm}^3$. The 50Ω asymmetric CPW line is used as a feed. The modified inverted feed line is inserted in to the ground plane, has vertical part of length L_1 and a horizontal part of length L_2 and circular arc shaped strip of radius R_3 . The vertical line section has gap of 0.7mm from the ground plane. A pair of circular arc shaped grounded metallic strips having different radius R_1 and R_2 are placed at diagonally opposite corners of the proposed antenna. The geometry of the proposed antenna structure is shown in fig1. Ansoft HFSS 14 is used for parametric analysis purpose.

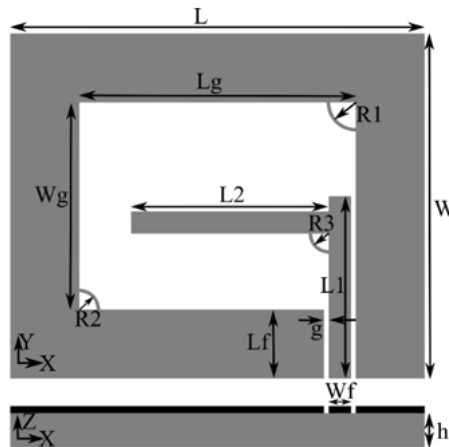


Fig.1. Geometry of the proposed CPW-fed antenna.

($L=60$, $W=50$, $L_g=40$, $W_g=30$, $L_f=10$, $L_1=26.4$, $L_2=28.6$, $W_f=3.2$, $g=0.7$, $h=1.6$, $R_1 = 3.95$, $R_2 = 2.75$, and $R_3 = 2.65$) (Unit: millimeters).

III. CIRCULAR POLARIZATION MECHANISM

Figure 2 shows how the proposed geometry has RHCP radiation in upwards direction with the help of magnetic current distribution on the dielectric part of the geometry. As the phase increase the rotation of the magnetic current is in anticlockwise direction. This indicates antenna is radiating RHCP wave in upwards direction. The radiation patterns are bidirectional in nature. If we see the rotation of magnetic current from $-Z$ direction it will be in clockwise direction. So the antenna is radiating LHCP wave in $-Z$ direction. We have achieved wide ARBW due to the closely spaced multi resonant orthogonal modes in the impedance bandwidth

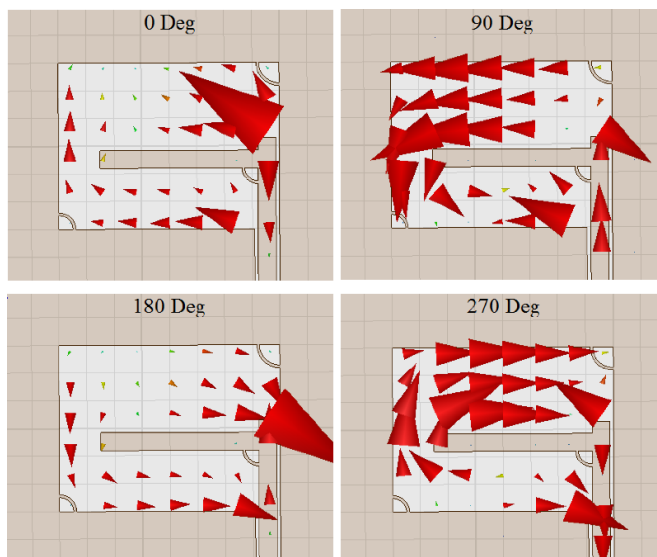


Fig. 2. Distribution of magnetic current at 3GHz for different values of $\omega t = 0^\circ, 90^\circ, 180^\circ$ and 270° .

IV. NUMERICAL ANALYSIS AND PARAMETRIC STUDY

To achieve wide ARBW a number of parameters have been simulated. By using parametric variation, we have achieved the prototype of the proposed antenna. The radiuses of grounded strips, protruded signal line's dimensions are examined to find their influences on the antenna impedance and axial ratio bandwidth.

A. The effect of radius of two grounded strips

Figure three shows the results of radius of upper grounded strip (R_1) on the returnloss and ARBW. With the increase of radius of grounded strip, better impedance matching is achieved but the circular polarization becomes worse at the central frequency of axial ratio bandwidth. Based on the above observation, R_1 is taken as 3.95 mm to get optimum performance.

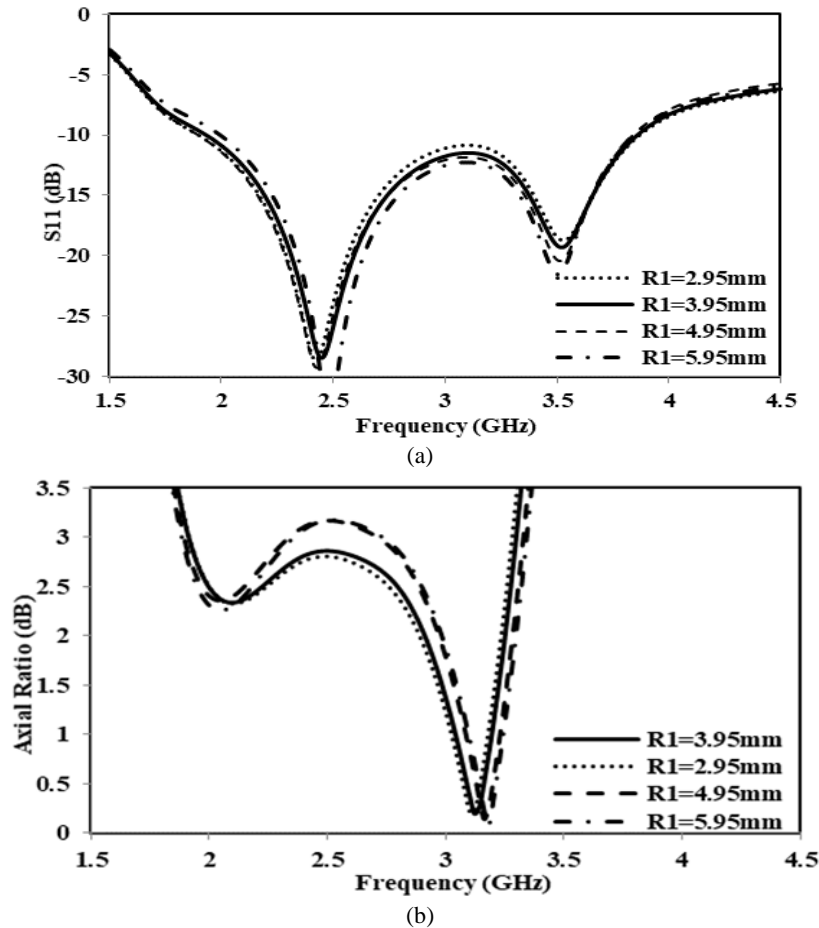


Fig. 3. Effect of the radius of upper grounded strip on antenna parameters: (a) Return losses; (b) Axial ratio (in +z direction).

Figure 4 shows the result of radius of lower grounded strip on the return loss and AR bandwidth. Radius of lower grounded strip (R2) is taken as 2.75 mm because in this case wide axial ratio bandwidth, and impedance bandwidth are obtained and axial ratio bandwidth falls within the impedance bandwidth.

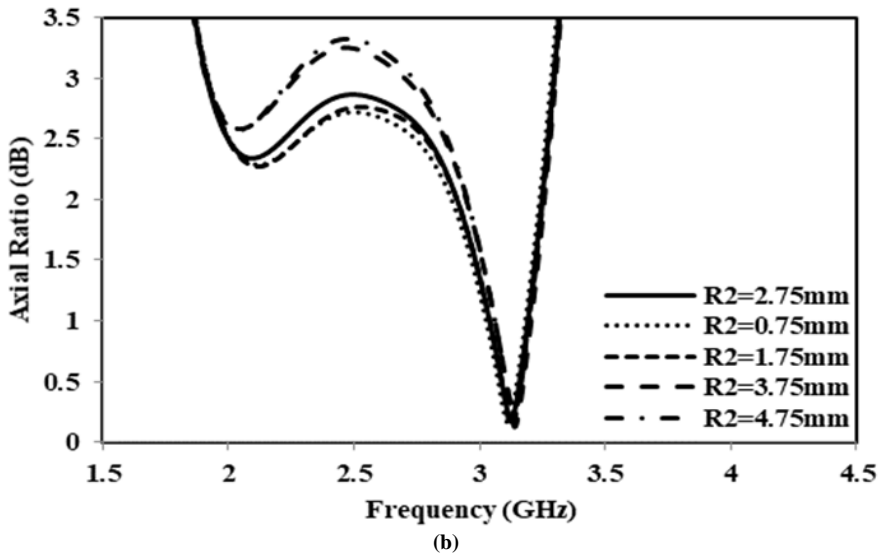
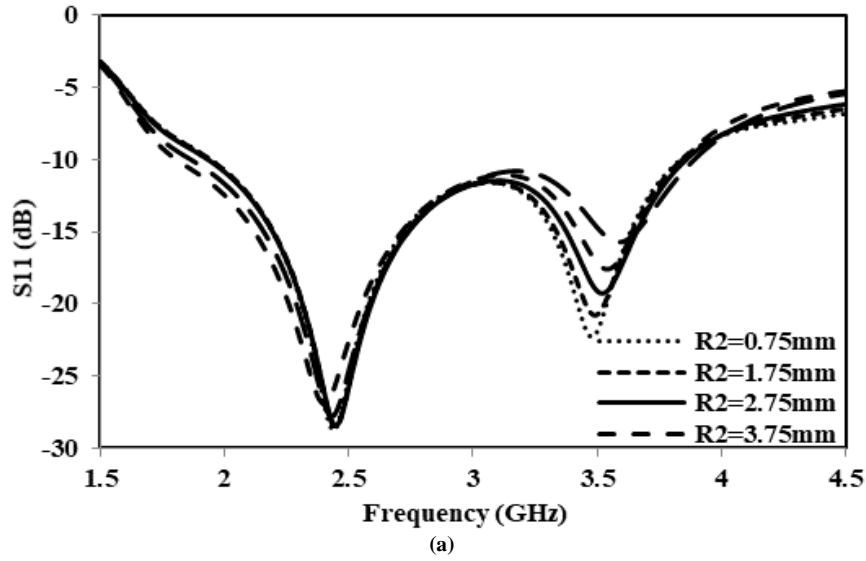


Fig. 4. Effect of the radius of lower grounded strip on antenna parameters: (a) Return losses; (b) Axial ratio (in +z direction).

B. The effect of the modified inverted L-type signal line's size

Figure five illustrates the impact of variation of parameter L_1 on RL & ARBW. By increasing L_1 , lower cut-off frequency of the RL bandwidth is reduced. The lower cut-off frequency mainly depends upon the length L_1 of the modified inverted

L-shaped signal line. But, it distorts the circular polarization at lower and central frequency of axial ratio bandwidth. So, to achieve optimum performance, L_1 is taken as 26.4 mm.

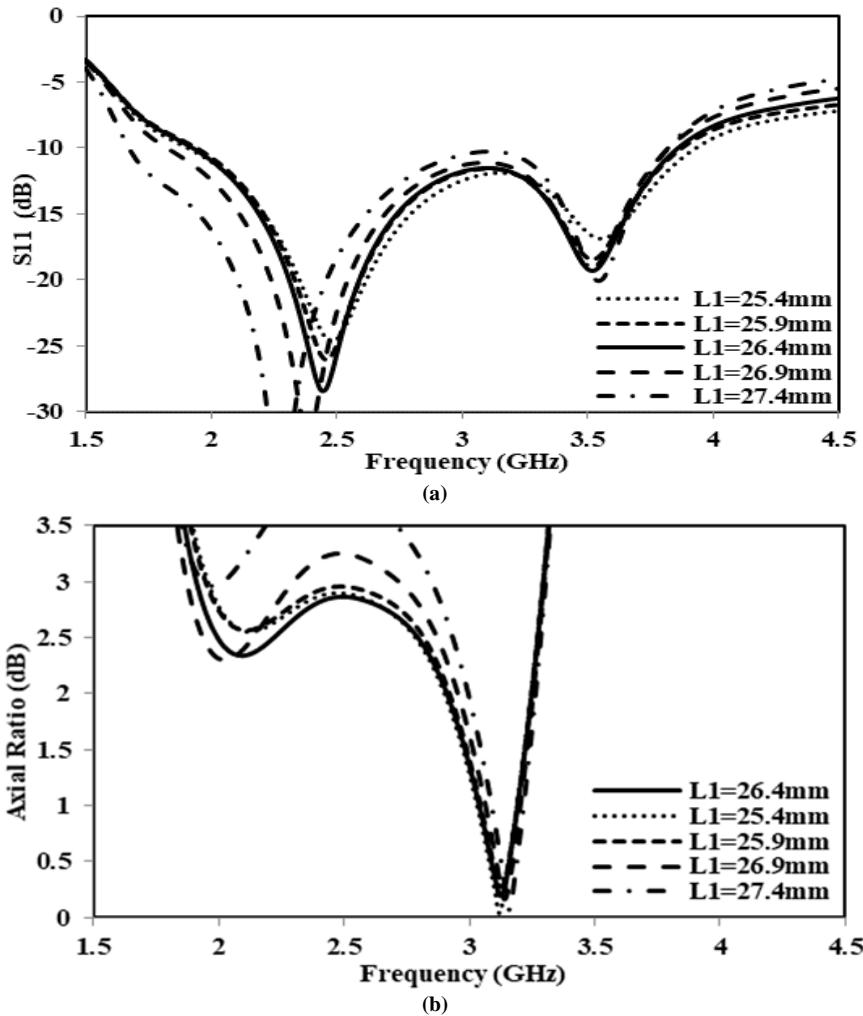


Fig. 5. Effect of the length L_1 of signal line of CPW feed on antenna parameters: (a) Return losses; (b) Axial ratio (in +z direction).

Fig. 6. Show the influence of the variation of the length L_2 on RL and AR bandwidth. While increasing the length L_2 , it improves the return loss at the first resonant dip and second resonant dip is shifted minutely at lower side. But, it distorts the circular polarization at lower and central frequency of axial ratio bandwidth. At $L_2=30.8$ mm circular polarization is good in overall axial ratio bandwidth but there is some mismatching between impedance and axial ratio bandwidth at lower cut off frequency. So $L_2=31.8$ mm is taken for good agreement between axial ratio and impedance bandwidth.

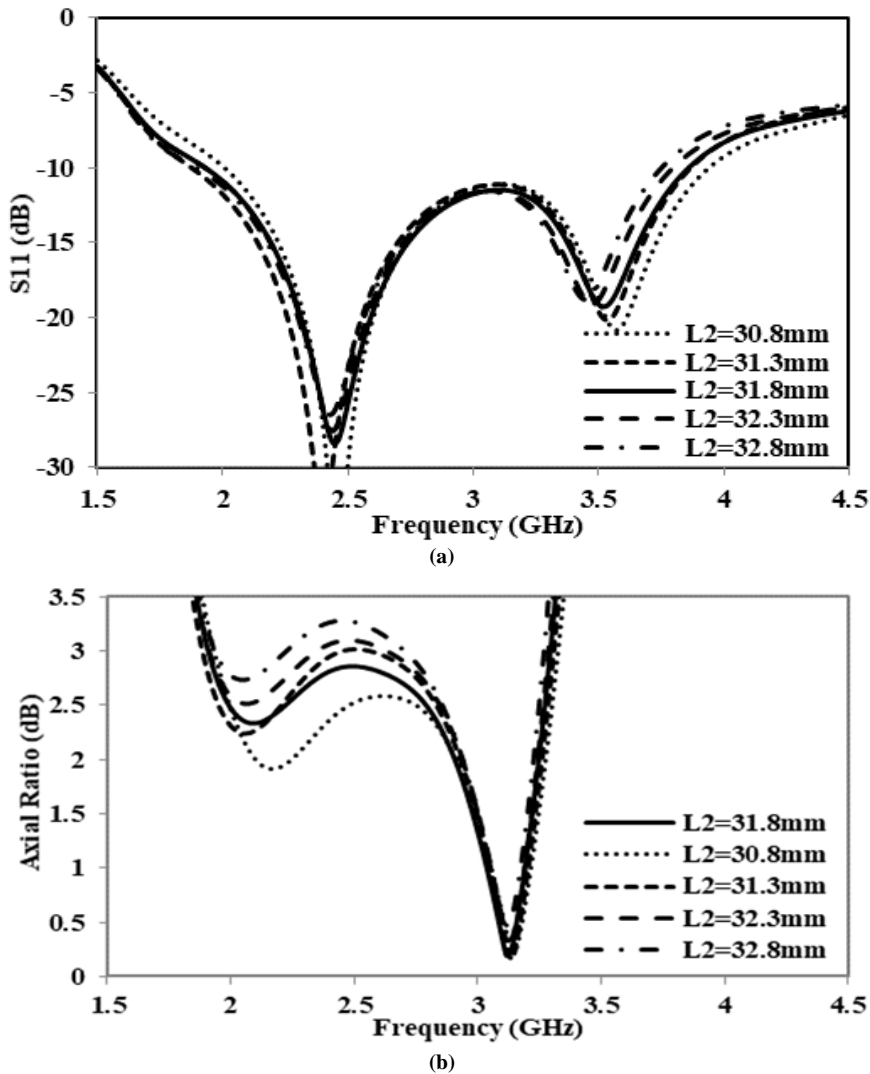
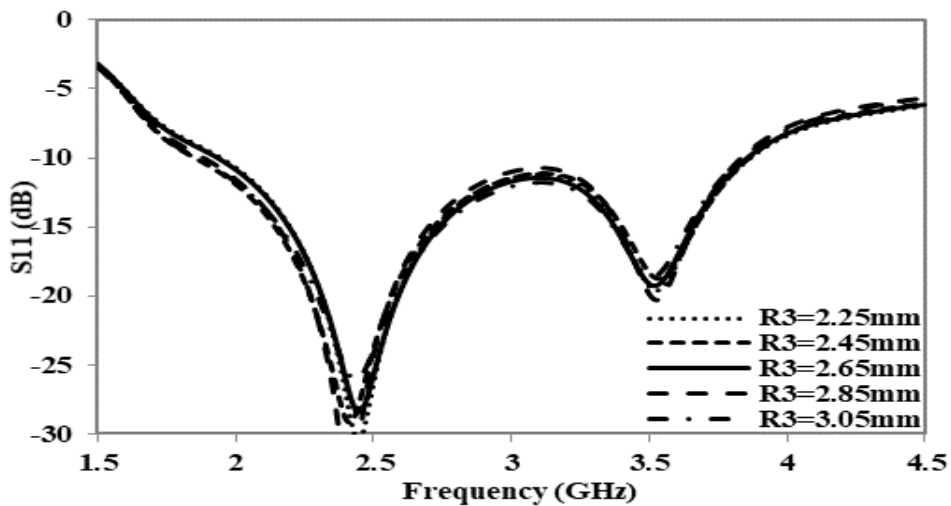


Fig. 6. Effect of the length L_2 of signal line of CPW feed on antenna parameters: (a) Return losses; (b) Axial ratio (in +z direction).

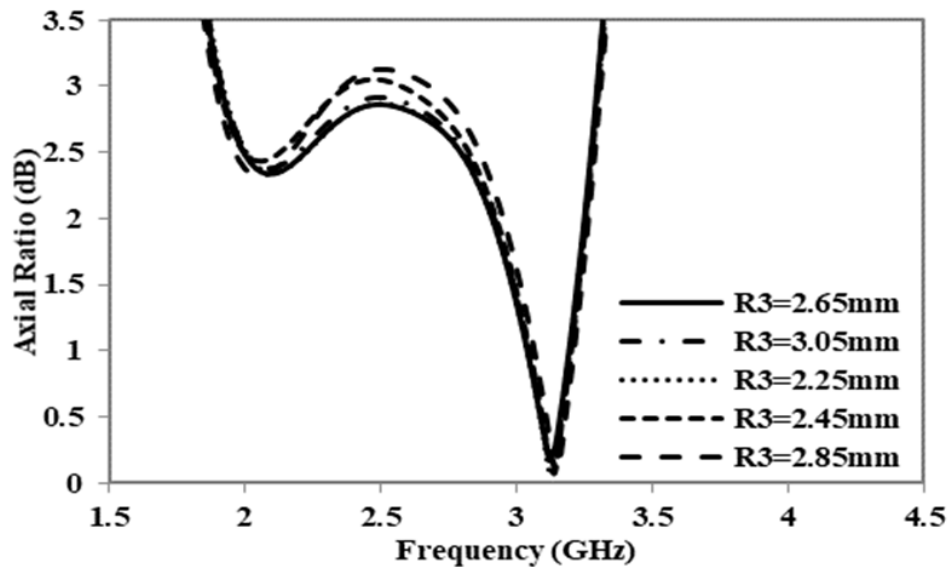
C. The impact of radius of signal line's strip

Figure seven shows the effects of variation of radius of line's circular arc shaped strip. By introducing this strip in to the modified inverted L-shaped line, matching between RL and AR bandwidth at lower cut-off frequency is improved. Without strip the circular polarization starts from 1.98GHz to 3.27GHz whereas the impedance bandwidth varies from 1.99GHz to 3.89GHz. At central frequency, the axial ratio exceeds above 3dB. After inserting and optimizing this circular

arc shaped strip of modified inverted L- shaped signal line of CPW- feed, the antenna shows circular polarization from 1.93GHz to 3.3GHz within axial ratio bandwidth ≤ 3 dB. The impedance bandwidth varies from 1.93GHz to 3.86GHz. This parameter is useful for matching between impedance and axial ratio bandwidth at lower cut-off frequency.

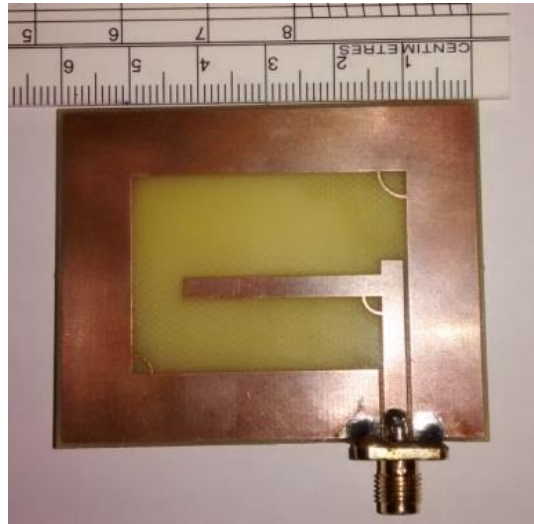


(a)



(b)

Fig. 7. Effect of the radius of signal line's strip on antenna parameters: (a) Return losses; (b) Axial ratio (in +z direction).



(a)

Fig. 8. Photographs of realized CPRSA with standard SMA.

V. RESULTS AND DISCUSSION

Figure 8 shows the fabricated antenna with SMA connector. The measured 10-dB return loss bandwidth is regarding 1.64GHz from 2.12GHz to 3.76GHz, that is fifty-six percent w.r.t. the frequency 2.9GHz as given in figure nine.

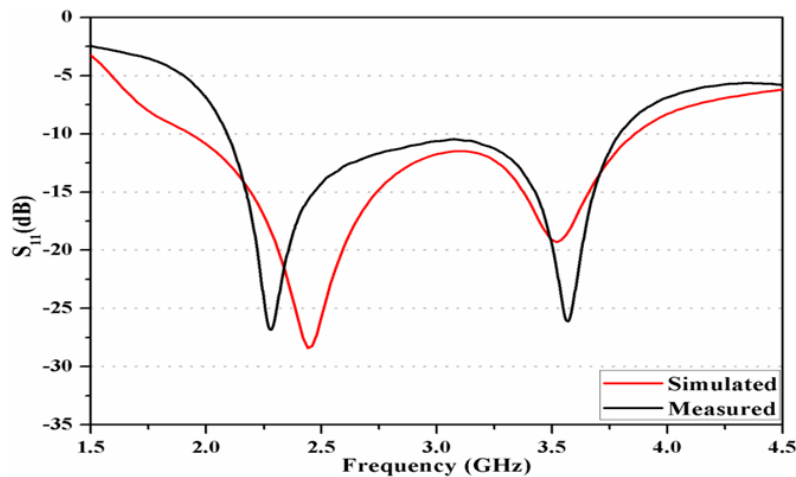


Fig. 9. Simulated and measured S_{11} (dB) of the proposed antenna.

The 3-dB ARBW is 1.09GHz from 2.2GHz to 3.29GHz corresponding to 40% with respect to the frequency 2.75GHz (central frequency of AR) as shown in the fig. 10. There is some mismatch between simulated and measured results. This is due to measurement error in anechoic chamber. Figure 11 shows the measured and simulated gain versus frequency, that deviates from 2.5dBi to 3.9dBi in CP bandwidth.

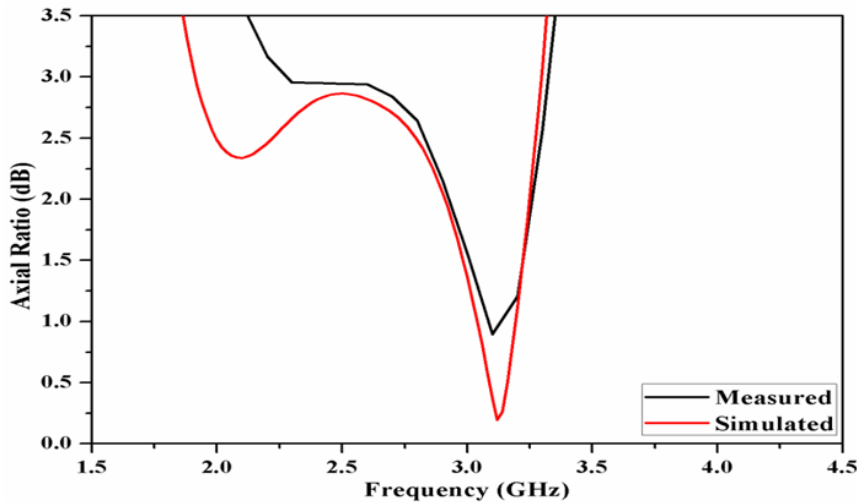


Fig. 10. Simulated and measured axial ratio in +z direction of the proposed antenna.

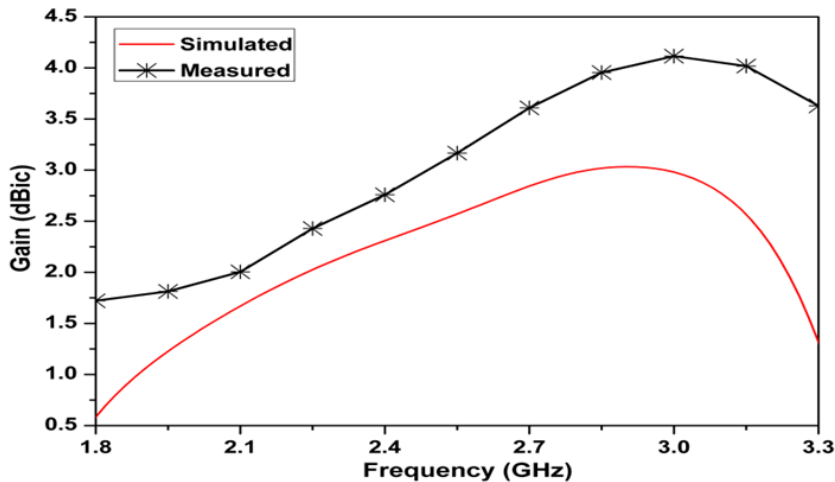


Fig. 11. Simulated and measured gain in +Z direction of the proposed antenna.

Figures 12 show the normalized radiation patterns of LHCP & RHCP at 2.75GHz. The difference between RHCP and LHCP radiation is approximately greater than twenty dB in the +Z direction in which the maximum radiation occurs. From the form of radiation patterns it's clearly shown that the antenna is diverging RHCP wave in upper direction and

LHCP wave in backward direction. We can also increase the gain and directivity of the antenna with the use of reflector at the back side of antenna.

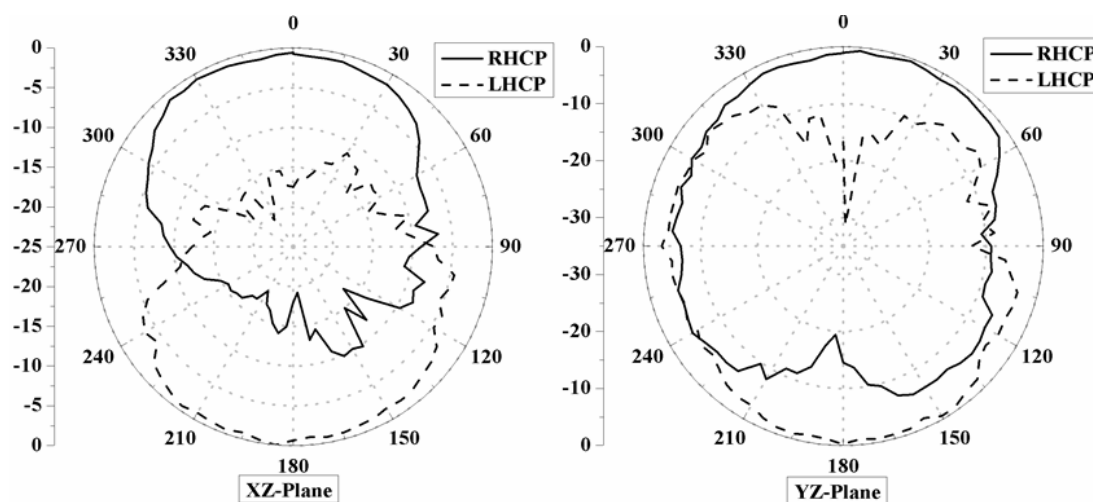


Fig. 12. Measured radiation patterns at 3GHz in both planes (YZ-plane and XY-plane) of the proposed antenna.

VI. CONCLUSION

The prototype of the proposed antenna for wideband circular polarization applications is presented in this article. Wide impedance bandwidth of 56% (2.12GHz-3.76GHz) and ARBW of 40% (2.2GHz-3.29GHz) has been achieved. The gain of antenna deviates from 2.5dBic to 3.8dBic in the ARBW. Therefore, there is useful application for WLAN/Bluetooth (2400-2484MHz) and WiMAX (2500-2690MHz) bands of the proposed antenna.

REFERENCES

- [1] R. K. Saini, and S. Dwari, "CPW-fed broadband circularly polarized rectangular slot antenna with L-shaped feed line and parasitic elements", *Microw. Opt. Technol. Lett.*, vol. 57, no. 8, pp. 1788-1794, Aug. 2015.
- [2] C.-H. Chen, and E. K. N. Yung, "Dual-band circularly- polarized CPW-fed slot antenna with a small frequency ratio and wide bandwidths" *IEEE Trans. Antennas Propag.*, vol. 59, no. 4, pp. 1379-1384, Apr. 2011.
- [3] R. K. Saini, P. S. Bakariya, and P. Kumar, "Coplanar waveguide fed dual-band, dual-sense circularly polarized square slot antenna," *Int. J. RF Microwave Comput. Aided Eng.*, pp.e21503, 2018.
- [4] Y.-M.Cai, K. Li, Y.-Z. Yin, and W. Hu, "Broadband Circularly Polarized printed antenna with branched microstrip feed," *IEEE Antennas Wireless Propag. Lett.*, vol.13, pp. 674-677, 2014.
- [5] R. K. Saini and P. S. Bakariya, "Dual-band dual-sense circularly polarized asymmetric slot antenna with f-shaped feed line and parasitic elements," *Prog. Electromagnet Res. M.*, vol. 69, pp. 185-195, 2018.
- [6] X. L. Bao and M. J. Ammann, "Dual-frequency dual-sense circularly polarized slot antenna fed by microstrip line," *IEEE Trans. Antennas Propag.*, vol. 56, no. 3, pp. 645-649, Mar. 2008.

- [7] R. K. Saini and P. S. Bakariya, "Dual-band dual-sense circularly polarized asymmetric slot antenna with f-shaped feed line and parasitic elements," *Prog. Electromagnet Res. M.*, vol. 69, pp. 185–195, 2018.
- [8] C. F. Jou, J.-W. Wu, and C.-J. Wang, "Novel broadband monopole antenna with dual-band circular polarization," *IEEE Trans. Antennas Propag.*, vol. 57, no. 4, pp. 1027–1034, Apr. 2009.
- [9] R. K. Saini, S. Dwari, and M. K. Mandal, "CPW-Fed dual-band dual sense circularly polarized monopole antenna," *IEEE Antennas Wireless Propag. Lett.*, vol. 16, pp. 2497–2500, 2017.
- [10] C.-J. Wang and Y.-C. Lin, "New CPW-fed monopole antennas with both linear and circular polarizations," *IET Microw. Antennas Propag.*, vol. 2, no. 5, pp. 466–472, 2008.
- [11] P. Kumar, S. Dwari, R. K. Saini, and M. K. Mandal, "Dual-band dual-sense polarization reconfigurable circularly polarized antenna," *IEEE Antennas Wireless Propag. Lett.*, vol. 18, pp. 64–68, 2019.
- [12] R. K. Saini and S. Dwari, "Dual-band dual-sense circularly polarized slot antenna," *International Conference on Electromagnetics in Advanced Applications*, Verona, Italy, 11–15 September, 2017, pp. 472–475.
- [13] Y. W. Liu and P. Hsu, "Broadband circularly polarized square slot antenna fed by co-planar waveguide," *Electron. Lett.* vol. 49, no. 16, pp. 976–977, Aug. 2013.
- [14] P. Kumar, S. Dwari, and R. K. Saini, "Triple band dual polarized CPW-fed planar monopole antenna," *Wireless Pers. Commun.*, 2017. <https://doi.org/10.1007/s11277-017-5115-1>.
- [15] Rohit Kumar Saini, "Polarization Reconfigurable Dual- Band Rectangular Slot Antenna.," *Journal of RF-Engineering and Telecommunications*, Frequenz, Volume 73, Issue 9-10, July, 2019, pp 339–351
- [16] C. Zhang, X. Liang, X. Bai, J. Geng, and R. Jin "A broadband dual circularly polarized patch antenna with wide beam width," *IEEE Antennas wireless Propag. Lett.*, 2014, vol. 13, pp. 1457–1460,.
- [17] R. K. Saini and S. Dwari, "Dual band dual sense circularly polarized square slot antenna with changeable polarization," *Microw. Opt. Technol. Lett.*, vol. 59, no. 04, pp. 902–907, 2017.
- [18] G. Zhao, L. N. Chen, and Y. C. Jiao, "Design of a Broadband Dual Circularly Polarized Square Slot Antenna," *Microwave and Optical Technology Lett.*, 2008, vol. 50, No. 10, pp. 2639–2642.
- [19] R. K. Saini, and S. Dwari, "Broadband dual circularly polarized square slot antenna," *IEEE Trans. Antennas Propag.*, vol. 64, no. 1, pp. 290–294, Jan. 2016.