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# Polarization Diversity Equipped Patch Antenna for IIoT, Remote Sensing, and Satellite Communication Applications

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## ABSTRACT

Compact, multiband patch antenna with dual kind of polarization is presented in this paper. Linear polarization and circular polarization are exhibited by the antenna in different resonating bands. The horn antenna tapering concept is implemented in this paper in order to achieve gradual transition in the impedance of the slot antenna, thereby resulting in triple resonating bands owing to a tapered slot causing gradual variation from 50 ohms to 377 ohms. A stub of $\lambda_g/2$ length generates even-odd modes which are orthogonal in the time domain, resulting in circular polarized behavior of the patch antenna. Band tuning provision is also provided in the antenna by embedding a narrow slit $w_s$. Length, width, and height of dimensions $0.78\lambda_g$, $0.78\lambda_g$, and $0.03\lambda_g$ $mm^3$ are fabricated for antenna on the FR4 substrate. The frequency ranges 2.68 GHz - 3.40 GHz is lower resonating band with circular polarization, whereas linear polarized upper bands are between 4.24 GHz - 5.56 GHz and 6.12 GHz - 6.89 GHz. The unique polarization response exhibited by different targets can be utilized to identify the targets with precision in IIOT, remote sensing, and satellite applications.

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## Introduction

Internet of Things (IoT) has become immensely popular in the last decade because of the advancement in communication technology. An antenna is an important component for the materialization of IoT and remote sensing applications. For the requirement of large bandwidth IoT applications, the research in the field of design of planar antennas for broadband/narrowband systems operating at 2.4 GHz and 5.2 GHz is becoming popular. In remote sensing, polarization adds a new dimension, which helps to gather more information for the accurate classification of objects. For the practical application of such antennas, wide bandwidth, size reduction, polarization diversity, and multiband and multimode operations are the important characteristics for the antenna design. Because of the huge demand in the domains of mobile and wireless communication, satellite applications, etc., planar patch antennas have attracted much attention because of size miniaturization, low profile, ease of fabrication, and light weight. For the design of planar antennas, there exist several feeding mechanisms such as feeding with a microstrip transmission line, coaxial probe, edge feeding, and the coplanar waveguide (CPW) feeding mechanism. Planar slotted antennas exhibit tremendous advantages over other types of antennas of a variety of structures for their suitable integration in the handheld miniaturized devices of the wireless domain, which is the key requirement for an IoT framework. A patch antenna with more than one resonating band is highly desirable in the modern-day wireless ISM band and satellite band operations. This communication is further improved at the level of various parameters if different kinds of polarizations are enabled in the antenna. In the field of IoT where a single trans receiver will be communicating and controlling multiple test objects, it is the need of the hour to reduce the requirements of the number of patch antennas at the controllers' end. This can be achieved majorly by incorporating features of the multiple resonating band in the antenna, incorporating multiple polarizations in the antenna.

However, it has to be ensured that co-cross polarization levels must be as low as 30 dB and below.

Reference[1] presents a multiband patch antenna with two kinds of polarizations, whereas reference[2] studies about the inductive slot-based concept for achieving better impedance matching. Wideband slot antenna with two operating bands, exhibiting different kinds of circular orientation of the electric field, fractal structure, and multiple bands is presented in references[3-6], while the concept of the folded slot and transition technique for orthogonal electric field mode generation has been presented in references[7,8]. However, complex patch designing with a large physical dimension of the substrate is the major limitation of the available literature.[9-11] Hence, an attempt has been made in this paper to present a patch configuration for better impedance matching between the feed port and the intrinsic impedance of free space, catering to the requirements of smaller dimensions, robust link owing to polarization diversity techniques.[12-14]

## Network And Analysis

The top image of the slot antenna is shown in Figure 1, whereas dimensions of the same are presented in Table 1. The CPW powering mechanism is used in this paper to energize the antenna.

### CP and Mode Analysis

Current vector illustration at 3.10 GHz confirming the circular polarized behavior of the lower resonating band is depicted in Figure 2. Clockwise rotation of current vectors in the azimuthal plane of antenna conforms the circular polarized behavior of the antenna for the lower operating band. Orthogonal modes generated in the antenna for the lower band also confirm the reason for achieving circular polarization. The portion of copper patch responsible for the major amount of radiations is studied in Figure 4. Red-colored areas confirm

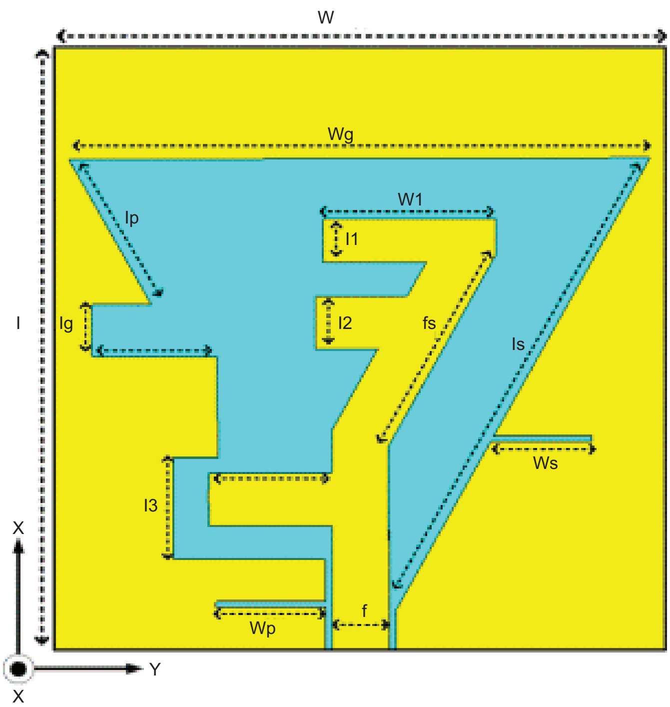


**Fig. 1: Proposed antenna top view.**

**Table 1: Antenna physical parameters (mm).**

| l1 | l2 | l3 | lg | lp | ls | f | fs |
|---|---|---|---|---|---|---|---|
| 2.40 | 2.90 | 5.70 | 2.90 | 9.30 | 29.0 | 3.20 | 12.10 |
| w1 | w2 | w3 | wg | wp | ws | l | W |
| 9.70 | 7.0 | 7.10 | 33.0 | 6.20 | 5.70 | 35.0 | 35.0 |

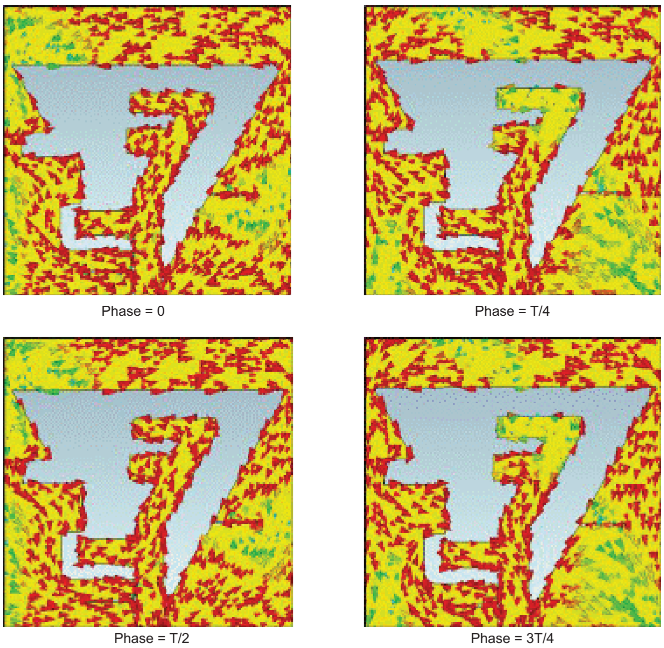


**Fig. 2: Current vectordistribution at 3.10 GHz.**

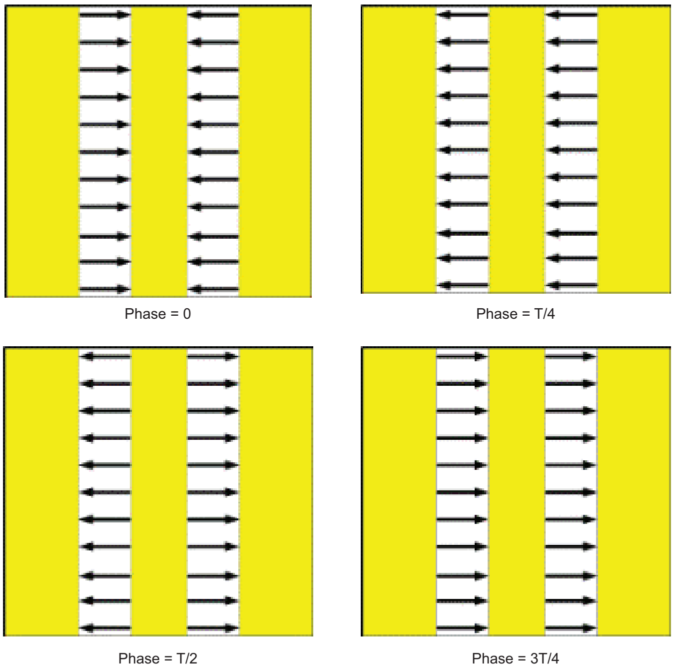


**Fig. 3: Mode distribution at 3.10 GHz.**

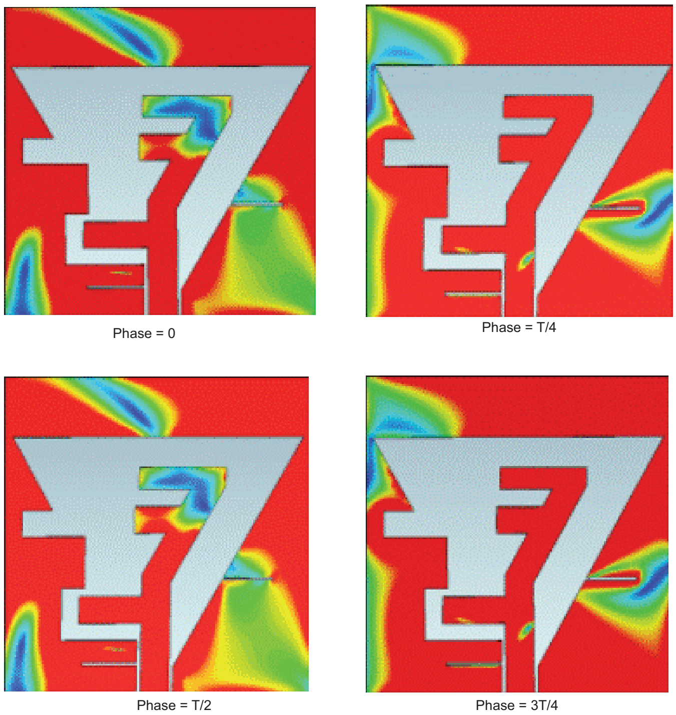


**Fig. 4: Magnetic current vectorbehavior at 3.10 GHz.**

the dominant areas of the patch contributing to circular polarization.

### *Antenna Evolution Analysis*

Antenna prototypes depicted in Figure 5 demonstrate the step-by-step method involved in realizing the antenna's final version. From Figure 6, multiband nature of the antenna can be inferred. The gradual transition of the feed line with respect to the tapered ground plane is responsible for excellent multiband characteristics of the antenna. Polarization properties of the proposed antenna is given in Figure 7, conforming to the inverted F-structure in the feed line responsible for the circular polarized nature of the antenna.

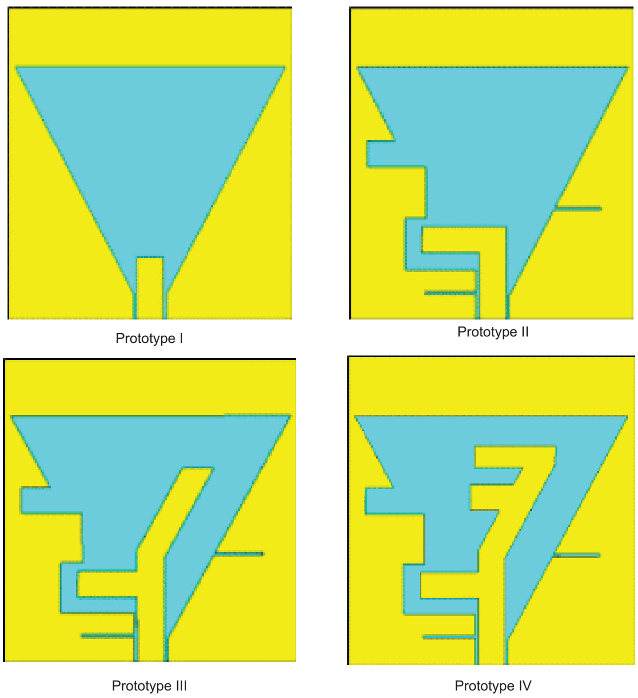


**Fig. 5: Antenna evolution mechanism.**

## Results And Discussions

Resonating bandwidth for the antenna extends from 2.55 to 3.82 GHz, 4.41 to 5.18 GHz, and 6.21 to 6.92 GHz. Voltage standing wave ratio shown in Figure 11 depicts the impedance matching of the antenna at the input feed port. Gain of the antenna for all the resonating bands is studied in Figure 12. Circular polarization of the antenna demands that the axial ratio must be less than 3 dB within the operating band. Figure 13 confirms the circular polarized behavior of the lower band and the linear polarized behavior of the upper band. Figure 14 illustrates the radiation pattern for the lower operating band, whereas Figure 15 illustrates the radiation pattern for the upper band.

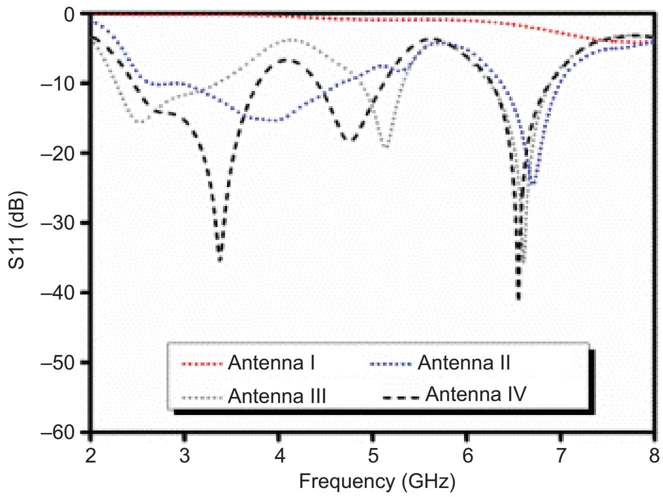


Fig. 6: Resonating band study during antenna evolution.

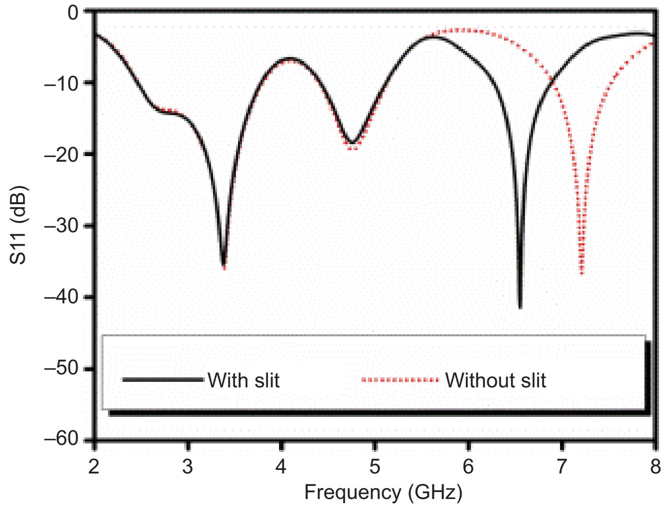


Fig. 9: Shift in resonant frequency of the upper band.

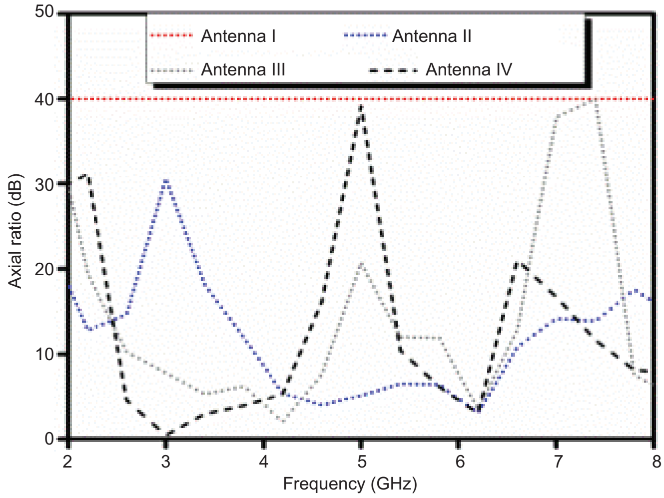


Fig. 7: Polarization study during antenna evolution.

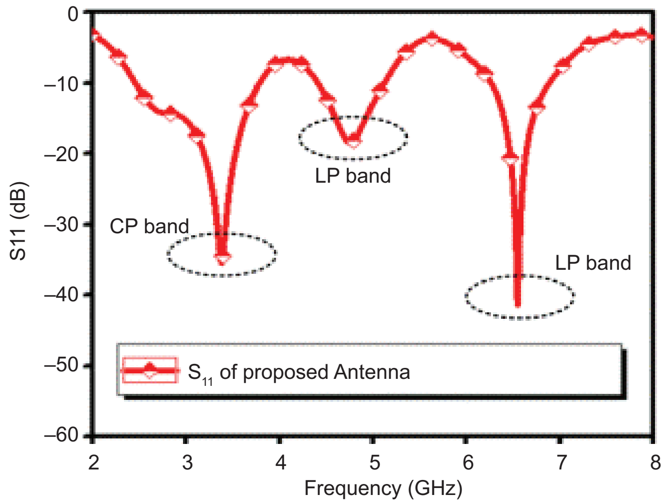


Fig. 10: S11 of antenna.

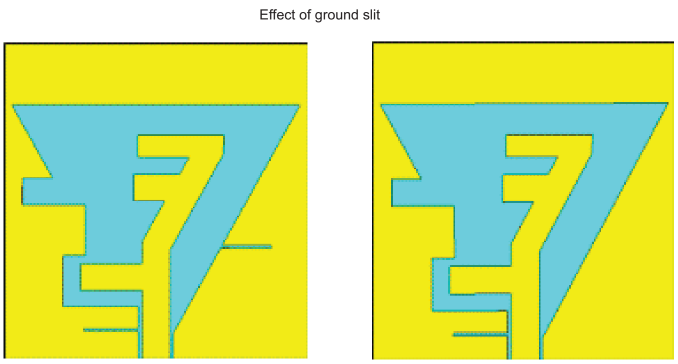


Fig. 8: Proposed antenna with and without the ground slit.

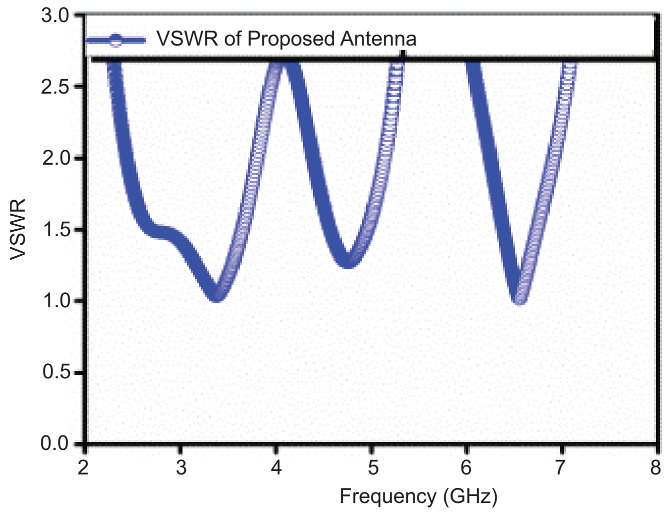


Fig. 11: VSWR of the antenna.

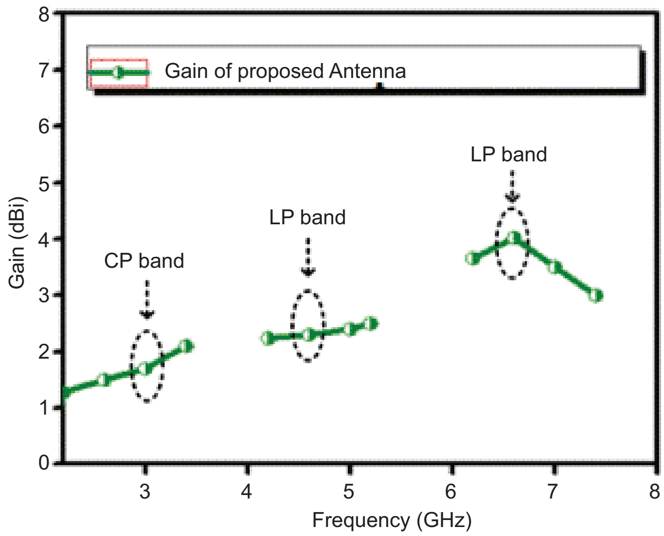


**Fig. 12: Gain of the antenna.**

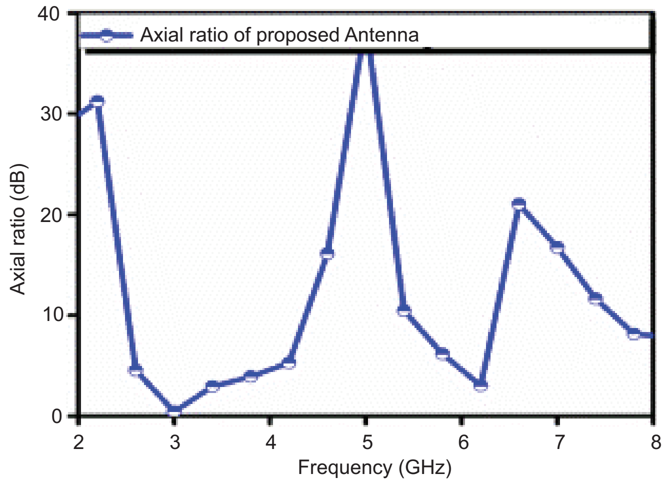


**Fig. 13: Axial ratio of the antenna.**

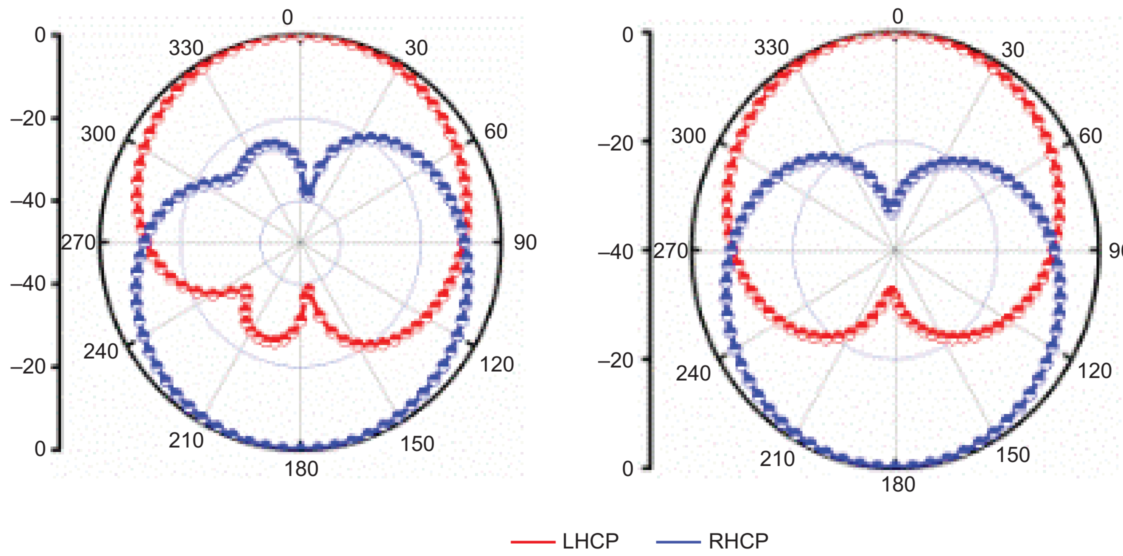


**Fig. 14: Radiation pattern for the antenna in both planes at 3.1 GHz.**

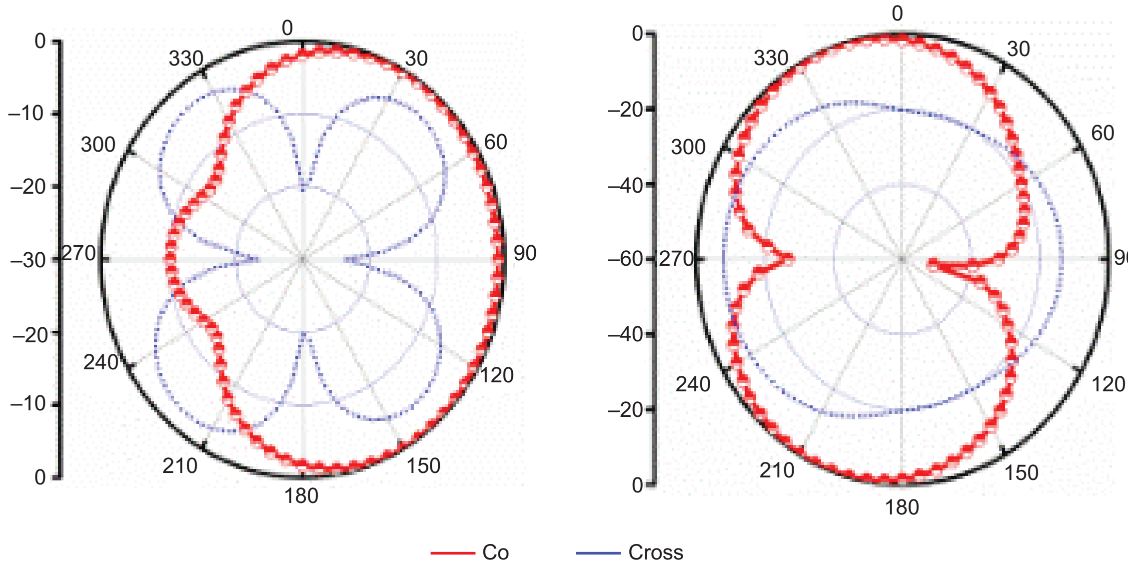


**Fig. 15: Radiation pattern for the antenna in both planes at 5.0 GHz.**

## Conclusion

Multiband patch antenna with three operating bands and two modes of circular polarization has been studied in this paper. The effect of gradual transition in the impedance of the slot on the resonating bands has been investigated. Flared feed line with respect to the ground plane result is in excellent impedance matching causing triple band behavior of antenna. Circular polarization for the lower band is generated by exciting odd-even modes in the phase quadrature. The lower most band is linear polarized with LHCP orientation, whereas the upper bands are linear polarized. The presented antenna can be implemented for IIoT, remote sensing, and satellite communication applications owing to the circular polarized monopole pattern. Also, the C-band with linear polarization can be effectively used for broadcasting data over the network of ground antennas.

## References

1. Li, G., Zhai, H., Li, T., Li, L., & Liang, C. (2013). CPW-fed S-shaped slot antenna for broadband circular polarization. IEEE Antennas and Wireless Propagation Letters, 12, 619–622. https://doi.org/10.1109/LAWP.2013.2261652
2. Lin, X. C., & Yu, C. C. (2008). A dual-band CPW-fed inductive slot-monopole hybrid antenna. IEEE Transactions on Antennas and Propagation, 56(1), 282–285. https://doi.org/10.1109/TAP.2007.905978
3. Sun, X., Zeng, G., Yang, H. C., & Li, Y. (2012). A compact quadband CPW-fed slot antenna for M-WiMAX/WLAN applications. IEEE Antennas and Wireless Propagation Letters, 11, 395–398. https://doi.org/10.1109/LAWP.2012.2192901
4. Naser-Moghadasi, M., Sadeghzadeh, R. A., Sedghi, T., Aribi, T., & Virdee, B. S. (2013). UWB CPW-fed fractal patch antenna with band-notched function employing folded T-shaped element. IEEE Antennas and Wireless Propagation Letters, 12, 504–507. https://doi.org/10.1109/LAWP.2013.2256455
5. William, J., & Nakkeeran, R. (2009, March 23–27). A novel compact CPW-fed wideband slot antenna. 2009 3rd European Conference on Antennas and Propagation, Berlin, Germany, 1471–1474.
6. Ouberri, F., Tajmouati, A., Zahraoui, I., Lakhssassi, A., Latrach, M., & Er-Rebyiy, R. (2020, December 2-4). A novel wideband CPW-fed square aperture monopole antenna with inverted-L grounded strips for wireless and satellite applications. 2020 IEEE 2nd International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS), Kenitra, Morocco, 1–5. https://doi.org/10.1109/ICECOCS50124.2020.9314499
7. Huang, Y., Xiaochuan, F., & Daniele, I. (2018, August 5–8). Miniaturized broadband CPW-fed folded-slot antenna for Wireless-LAN and Wi-MAX bandwidths. 2018 IEEE Asia-Pacific Conference on Antennas and Propagation (APCAP), Auckland, New Zealand, 89–90. https://doi.org/10.1109/APCAP.2018.8538056
8. Ding, Y., Jiao, Y. C., Fei, P., Li, B., & Zhang, Q. T. (2011). Design of a multiband quasi-Yagi-type antenna with CPW-to-CPS transition. IEEE Antennas and Wireless Propagation Letters, 10, 1120–1123. https://doi.org/10.1109/LAWP.2011.2170950
9. Flammini, F., & Trasnea, G. (2025). Battery-powered embedded systems in IoT applications: Low power design techniques. SCCTS Journal of Embedded Systems Design and Applications, 2(2), 39–46.
10. Velliangiri, A. (2024). Security challenges and solutions in IoT-based wireless sensor networks. Journal of Wireless Sensor Networks and IoT, 1(1), 8–14. https://doi.org/10.31838/WSNIOT/01.01.02
11. Abdullah, D. (2024). Strategies for low-power design in reconfigurable computing for IoT devices. SCCTS Transactions on Reconfigurable Computing, 1(1), 21-25. https://doi.org/10.31838/RCC/01.01.05
12. Alaswad, H., & Hooman, K. (2025). Thermal management in electronics using advanced technologies for heat transfer. Innovative Reviews in Engineering and Science, 3(1), 19–25. https://doi.org/10.31838/INES/03.01.03
13. Kavitha, M. (2024). Design and performance analysis of a wideband MIMO antenna array for 5G millimeter-wave applications. National Journal of RF Circuits and Wireless Systems, 1(1), 1–10.
14. Karthika, J. (2025). Sparse signal recovery via reinforcement-learned basis selection in wireless sensor networks. National Journal of Signal and Image Processing, 1(1), 44–51.