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Star Shaped Circularly Polarized Patch Antenna for Wireless Data Communication

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Abstract

In this paper, star shaped circularly polarized micro-strip patch antenna is presented and also measure the circular polarization for ensures flexibility of the antenna. Various techniques have been used during design of patch antenna. The proposed antenna is designed for 1.9 Mobile application and 2.4, 3.2, 5.2 GHz Wi-Max and Wi-Fi applications. The maximum gain of antenna is 6.14 dB which is good for circularly polarized antenna. The effect of antenna dimensions such as length, width and substrate thickness on the radiation pattern, beam width and bandwidth has been investigated.

Keywords: *C*ircularly *polarized antenna, micro-strip patch antenna, and octagon-star shape*.

1. Introduction

In wireless communication system antenna is the element which plays important role. Nowadays, micro-strip patch antennas are widely used due to their light weight, low cost and conformability. The aim of this paper is to design and fabricate a Patch Antenna with circular polarization and study the parametric analysis with respect to length, width and substrate thickness on the radiation pattern, beam width and bandwidth [1]. The concept of beam reconfiguration is discussed, the radiation pattern rotating around an axis allowing transmission or reception from any spherical angle. The simple method switching method is suggested without semiconductor devices. By employing odd and even modes in a coplanar waveguide, a dual-polarization is achieved by circularly polarized antenna. Greater size reduction and flexibility of the feed network, when two signals are transmitted by a solo multi-mode communication line [2].

The asymmetries of structure provide circular polarization. The bandwidth of the antenna can also increase with different structural modification. The truncated corners of the patch are appeared due to slit of triangular shaped are inserted which shows circular polarization etc. The Aperture Coupled feeding is discussed in structural part of antenna. For multi bands, good CP Characteristics explained with radiation pattern [3].

The two antenna elements have advantage of compactness at 5.8 GHz for wireless applications. The only one left-handed unit cell is designed in structure of antenna. The surface wave shows mutual coupling reduction in-between two antenna element due to a simple defected ground structure. It has coupling isolation which separated by 1.8 mm distance of 45dB. For the same frequency; reduced size can be obtained over patch antenna. The correlation coefficients of MIMO antenna of two corresponding elements are found to be 55dB [4].

The MIMO antenna at 2.5 GHz constructed using monopoles of symmetry with separated edges. The ground plane is combined with two slits bent. The reduction of the mutual coupling and effect on the reflection coefficient are found at the lower frequencies using slits bent. Because of two slits in coupled fed can be considered by widen the impedance bandwidth at the higher frequencies. The ground plane can cut from triangle structure. The effects of human body parts like head and hand affect the antenna performance in real life [5].

2. Antenna Design

Nowadays, Microstrip antenna is popularly used. Microstrip patch is one of the antennas which are used popularly for circular polarization. The transmission loss is reduced by Polarization matching which is achieved by aligning the orientation of the wave propagation in both the transmitting and receiving antennas. A micro-strip antenna is a resonator type of antenna it operates on single mode operation which gives linear polarization. There are two types of feeding techniques such as contacting and non-contacting type. In this antenna we used micro-strip feed line technique due to the advantage of easy to fabricate, easy to match and also easy to model.

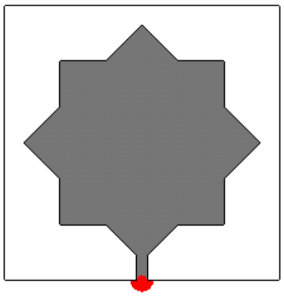


Figure1: star-shaped patch

For circular polarization, there is a necessity of two orthogonal components of electric field. These components must be equal in amplitude with phase shift of ±90°. There are two most often used methods for generating circular polarization. One is to use a disruption element incorporated with the radiator, which generates dual orthogonal modes and another method; a radiator with two inputs having orthogonal phase shift can be implemented. Fig. 1 indicates the geometry of the circularly polarized star shaped patch antenna. The construction of this antenna is done on the square substrate. The patch has the star shape which is on the top of the substrate. Star-shape can be designed by the superimposition of two square patches. There is an angular displacement of 45° between two square patches for getting perfect octagon star-shape. The length of one patch is L and other square has the length L+Δl.

3. Results and Discussions

3.1 Design A

The designed antenna has the dimension L=40 mm, W=40 mm, and the substrate size of L=47.7mm, W= 47.7 mm. The result has been simulated using the EM software.

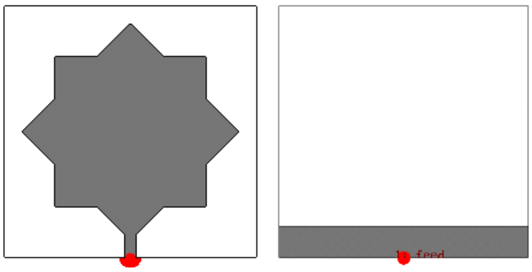


Figure 2: Star shaped antenna with feed line

Figure2 shows the octagon star-shape patch which is designed on the square substrate. Partial ground structure is used instead of full ground make antenna monopole like structure. The antenna is feed by using Microstrip feed line having 3 mm thickness.

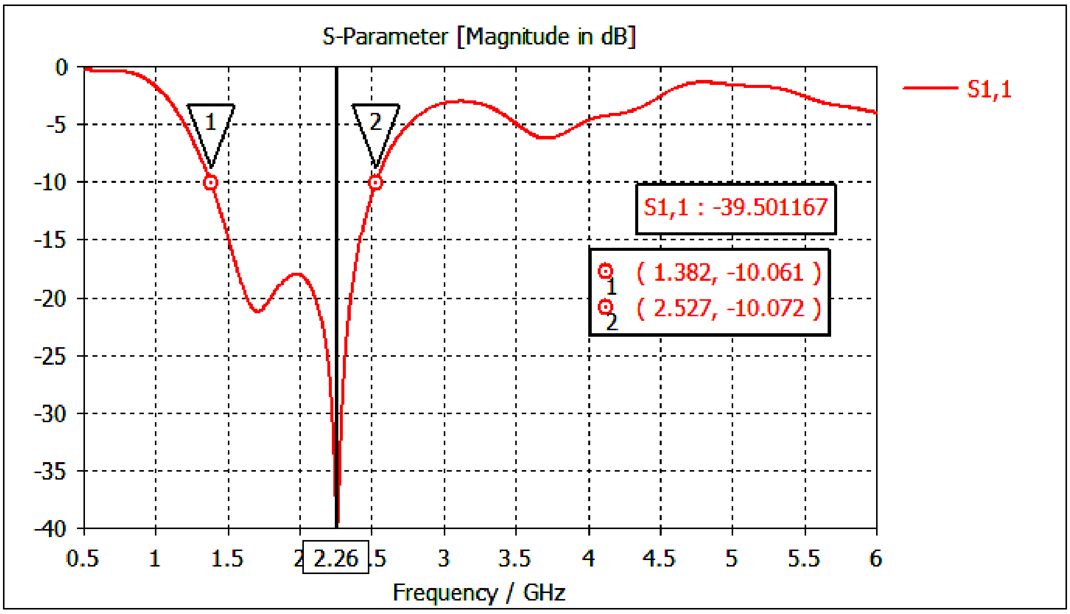


Figure3: S-parameter

The simulated s-parameter depicted in fig.3, we got the operating frequency band from 1.3 GHz to 2.5 GHz with resonance frequency at 2.26 GHz. When the l and $l+\Delta l$ decrease, resonating frequency is f=2.26 GHz which is very close to the expected frequency and relatively wide impedance bandwidth is obtained. At resonance antenna shows better impedance matching and hence VSWR is found to be 1.021 very close to 1.

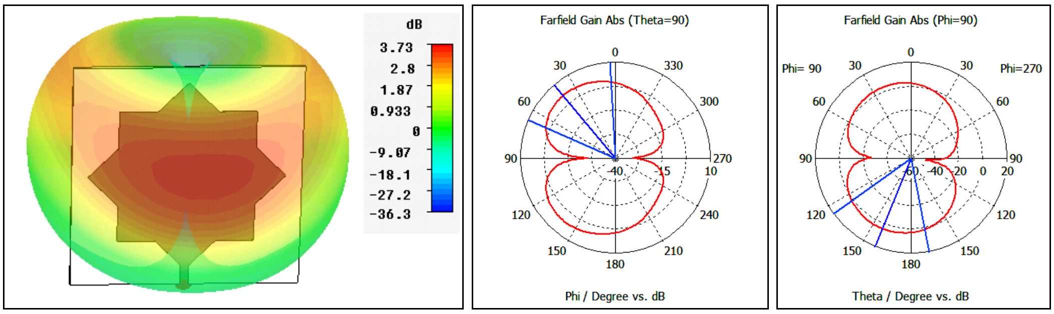


Figure 4: 2D and 3D Radiation Pattern

The Radiation pattern shows that, almost equal radiation in azimuthal as well as elevational direction which leads to circular polarization. The maximum gain achieved by the antenna is 3.75 dB.

3.2. Design B

The antenna structure is optimized by reducing the size of antenna by 25 %. The new dimension of antenna is 30 x 30 mm2. The modified structure shows better results than previous one. Here we got two different frequency bands i.e from 1.9 -3.54GHz and second range is from 4.91-5.22GHz with resonance frequency of 2.37GHz, 3.17GHz and 5.06GHz.

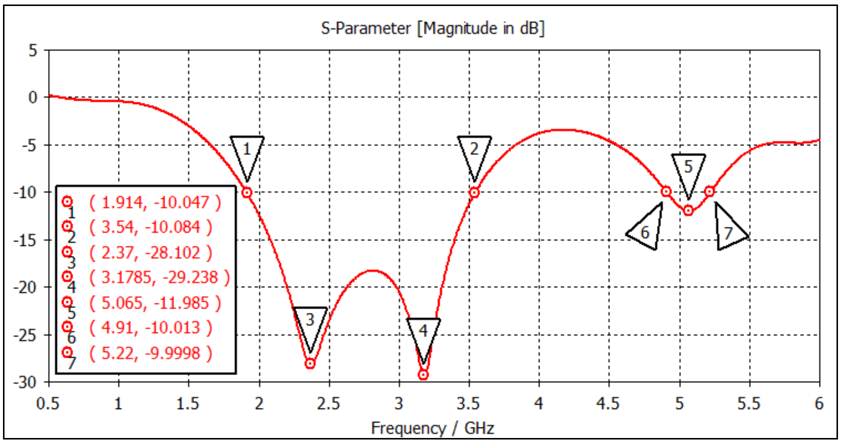


Figure 5: S-parameter of modified structure

We got better VSWR at resonating frequencies; which is very closer to 1 (fig*ure 6*). The impedance is very closer to 50 Ω indicating better impedance matching of antenna (fig*ure 7*).

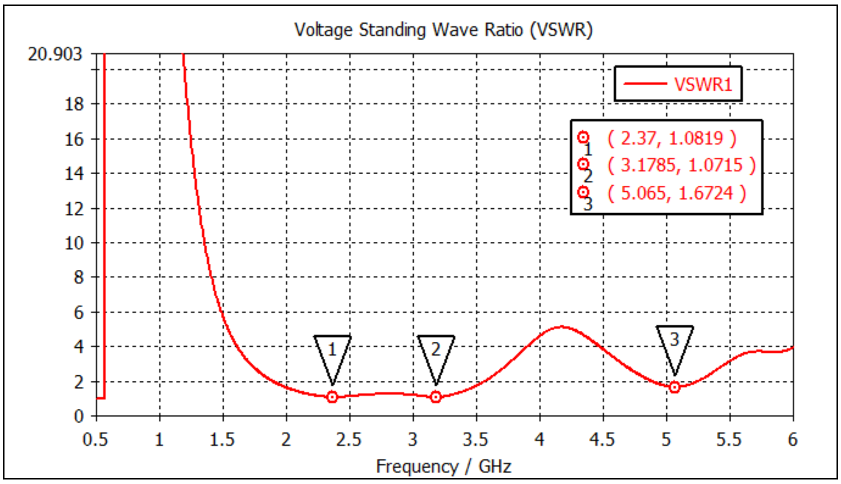


Figure 6: VSWR of modified structure

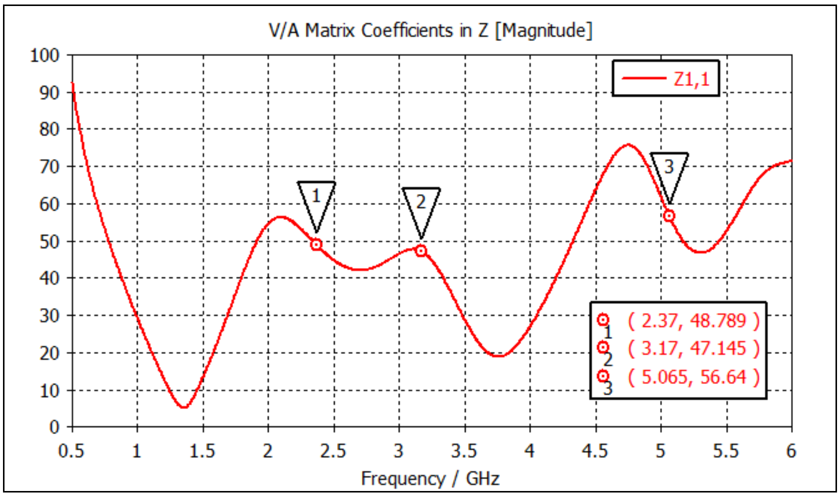
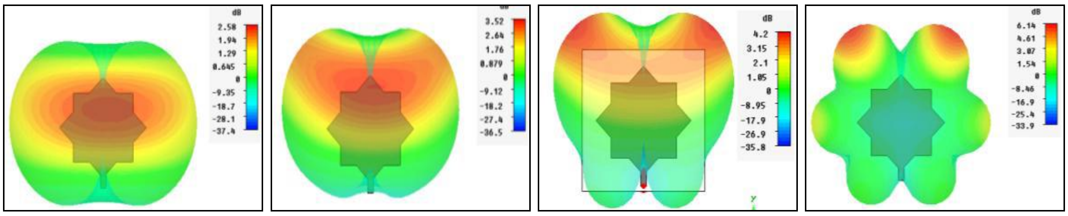


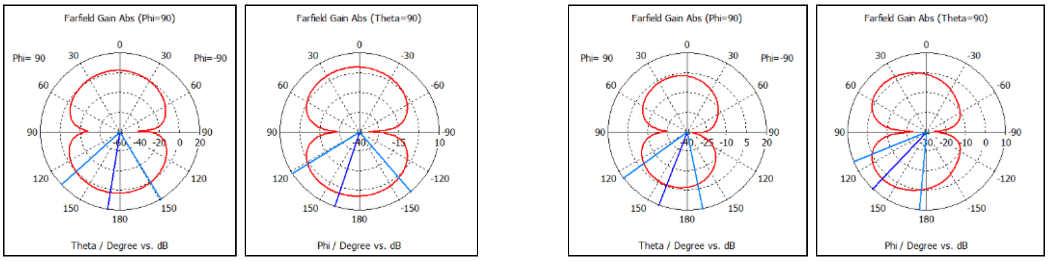
Figure 7: Impedance of modified structure

The radiation pattern of antenna is indicated by figure 8 & 9. The gain of antenna is gradually increased from lower frequency band to higher frequency band. The maximum gain achieved by antenna is 6.14 dB which is very good value as far as the multiband antenna concern. The pattern becomes very clear and diversified at higher frequencies. The better circular polarization is achieved.

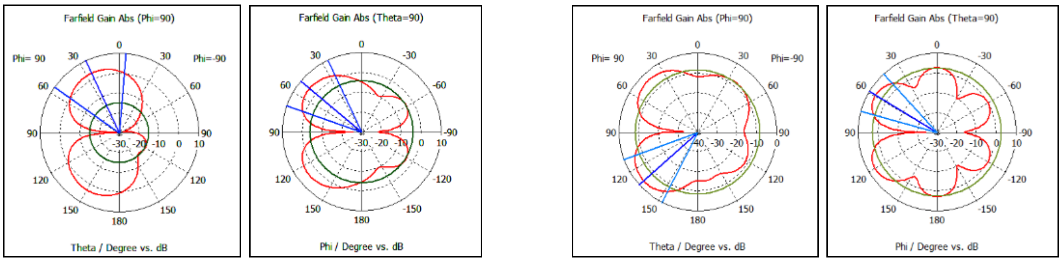


a) F= 2.4 GHz **b) F= 3.2 GHz** **c) F= 3.6 GHz** **d) F= 5GHz**

Fig 8: 3D radiation pattern of modified structure



a) F= 2.4 GHz **b) F= 3.2 GHz**



c) F= 3.6 GHz **d) F= 5 GHz**

Figure 9: 2D radiation pattern of modified structure

4. Circular Polarization

The Circular Polarization can be measured using two orthogonal components, Such as left-hand circular and right-hand circular. This component having the intended sense of rotation (left or right) this is called as co-polarization component. The undesirable component with opposite polarization is called cross-polarization component. The combination of co-polarization and cross polarization determines the quality of circular polarization and it is related with axial ratio (AR). To know about the circular polarization the term axial ratio must be use. Ideally the value of axial ratio must be 0 dB. But generally we consider it as up to 3dB. From figure 10 , it is observed that for the desired frequency range we get gain below 3dB which shows circular polarization of antenna.

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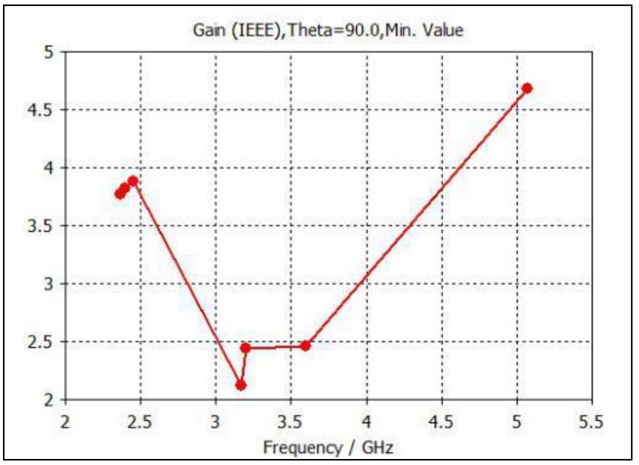


Figure 10: circular polarization of octagon star shape patch

The power flow diagram indicates that, the antenna starts accepting the power from 1 GHz onwards. Out of this accepted power it radiates maximum power. The efficiency of antenna is varies from 80 % to 96 % in various bands.

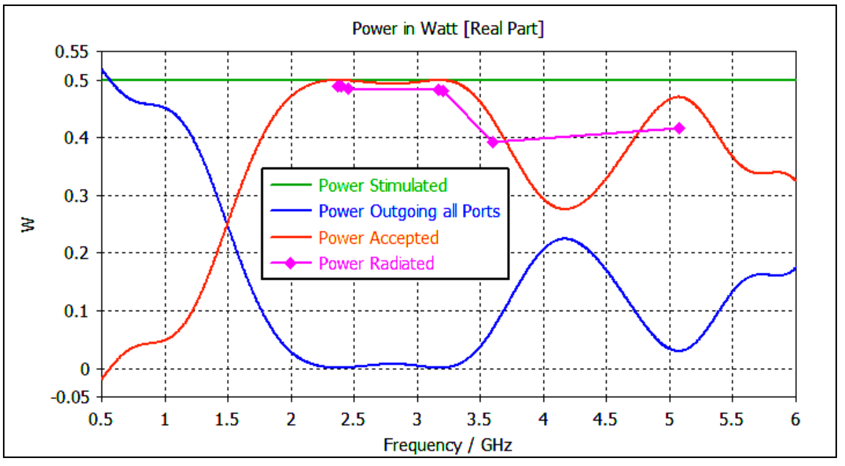
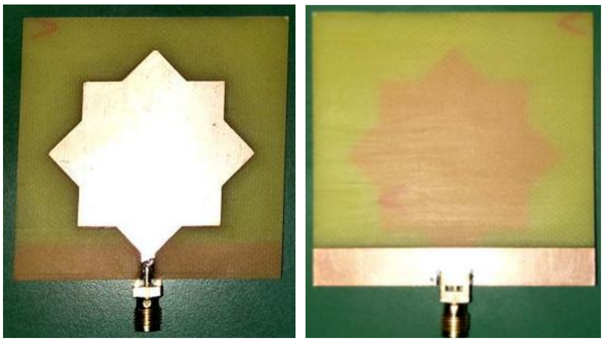


Figure 11: Power pattern

5. Fabricated Prototype

A prototype of the antenna is presented in figure 12. Fine fabrication has been done with the help of PCB milling machine.



(a) (b)

Figure 12 :(a)Top View of fabricated octagon star shape patch
(b) Bottom View of fabricated octagon star shape patch.

The measured results are very closer to simulated results indicating fine fabrication of the antenna. The measured results confirmed the simulated results; the slight variation in results is due to the losses across the dielectric substrate.

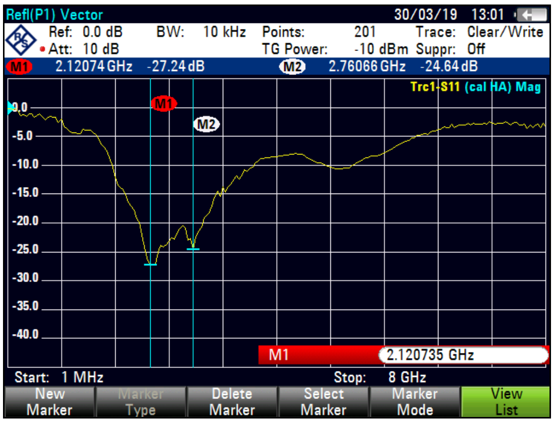


Figure 13: Measured S11 of fabricated octagon star shape patch.

Figure 14: Measured VSWR of fabricated octagon star shape patch

6. Conclusion

The circularly polarized microstrip patch antenna has been designed which shows multiband response. The first band operate over the frequency range of 1.9 to 3.54 GHz while the second band operate over the frequency range is from 4.91 to 5.22 GHz with resonance frequencies of 2.37 GHz, 3.17 GHz and 5.06 GHz. The antenna design has been fabricated and the measured results validate the simulated results. The Antenna operates over 1.9 GHz frequency band is useful for Mobile communication while 2.4, 3.2, 3.6 & 5.2 GHz frequency bands are useful for Wi-Fi and Wi-Max application.

7. References

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