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Circularly Polarized Dual Frequency Hexagonal Microstrip Patch Antenna for X-band Applications

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Abstract: A low profile Hexagonal microstrip patch antenna is proposed which operates in the X-band and resonates at 9.5GHz. It is observed to be linearly polarized with an axial ratio of 35.03 dB. Without changing the feed mechanism, circular polarization is achieved along with dual frequency operation. By cutting a slot in the hexagonal patch which extends up to edge of the patch, we obtain the resonant frequencies at 9.05 GHz and 10.05 GHz. The axial ratio for this patch antenna is found to be 2.85 dB. Since this value is below 3 dB, the antenna is said to be circularly polarized.

Keywords: Hexagonal Patch, Axial Ratio, Circular Polarization, Linear Polarization.

I. INTRODUCTION

Microstrip patch antennas have become very popular due to their low profile, low cost, conformability and ease of fabrication. They are also available in different variants like multi frequency, various shapes and polarizations. Although circular and rectangular shapes are more common [1], this paper focuses on hexagonal microstrip antenna design, which operates in the X-band.

One of the important antenna parameters to be considered is polarization. In simple terms, polarization is the orientation of electric field. Polarization can be linear or circular [2]. In linear polarization, the electric field propagates either horizontally or vertically. The magnetic field is always orthogonal to the electric field. Depending on the plane of polarization, the linear polarization is further divided into Horizontal linear polarization and Vertical linear polarization [3] as shown in figure below.

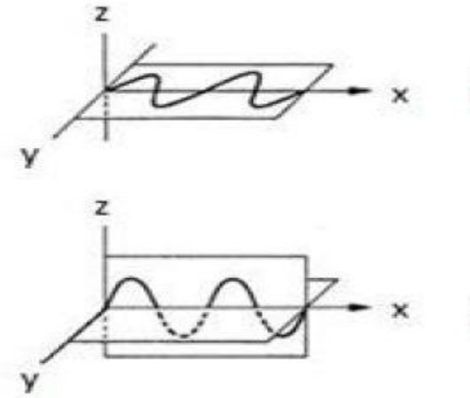

Fig.1 Horizontal and Vertical linear polarizations respectively

In circular polarization, the electric field has two components orthogonal to each other. Both of the components have equal magnitude and thus the locus traced by electric field vector tip is a circle [4]. As the wave approaches the observer, it appears to be rotating clockwise or counter clockwise. On this basis, the wave can be called right hand circular polarized or left hand circular polarized respectively.

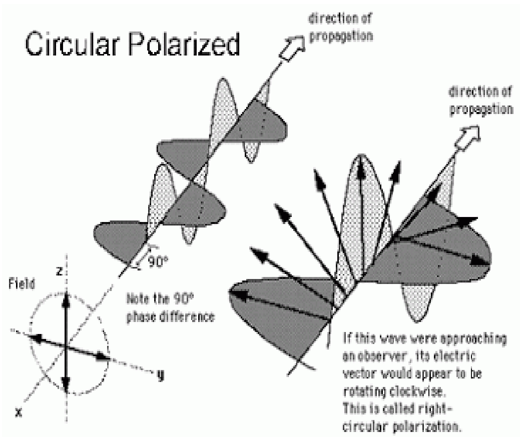

Fig. 2 Circular Polarization

The parameter which describes the type of polarization is Axial Ratio [5]. In an ellipse, axial ratio is the ratio of major axis to minor axis. If the ratio is equal to 1, the ellipse becomes circle. Thus for circular polarization, axial ratio must be 1. In logarithmic scale, it should be 0 dB. But practically, an axial ratio below 3 dB is acceptable for circular polarization [6]. Any value of axial ratio above 3 dB is considered as linear polarization.

There are several techniques which yield circular polarization. In dual feed techniques, there is a phase difference of 90° between the two feeds with same amplitude. In single fed patches, circular polarization can be obtained using truncations, corner feeds or inclined slots in the patch[7][8][9].

II. ANTENNA DESIGN

For drawing a hexagonal patch, an equivalent circular patch is considered which encloses the hexagon. The radius of the equivalent circular patch is calculated as [10]

$$f_r = \frac{1.84118c}{2r_c\pi\sqrt{\varepsilon_r}}$$

Where, f_r =resonant frequency
c=velocity of light
r_c =equivalent radius of circular patch
ε_r =dielectric constant of substrate
The patch is to be designed for a resonant frequency of 9.4 GHz. By substituting in above equation, we obtain r_c =4.45mm. The hexagonal patch is drawn and simulated using HFSS 14 software.

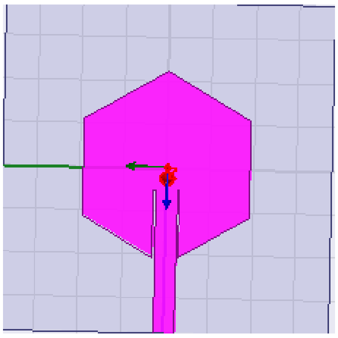

Fig.3 Simulated simple hexagonal patch

For obtaining dual frequency circular polarization, an inclined slot is cut and extended up to one of the edges of the hexagon.

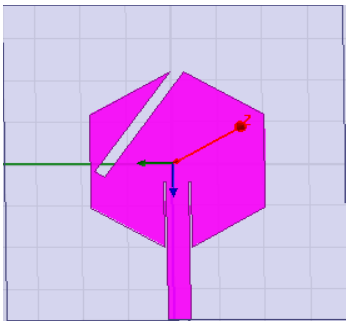

Fig. 4 Simulated dual frequency patch with circular polarization

III.RESULTS

The single frequency hexagonal patch is simulated and it is found to resonate at 9.5 GHz with a return loss of -25.63 dB.

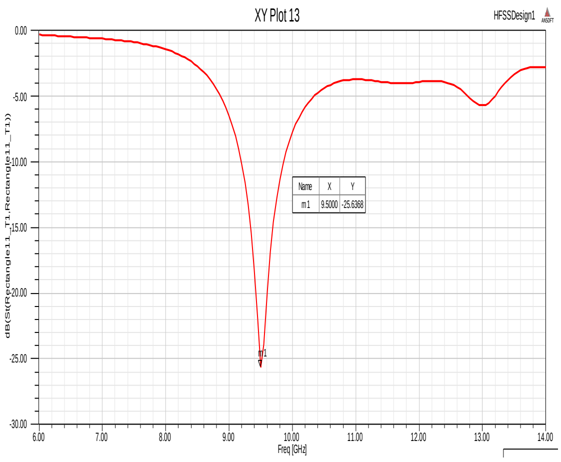

Fig. 5 Return loss of simple hexagonal patch

The axial ratio in dB is observed against theta values and it is found to be 35.03 dB which is far greater than 3 dB. Thus the hexagonal patch is linearly polarized.

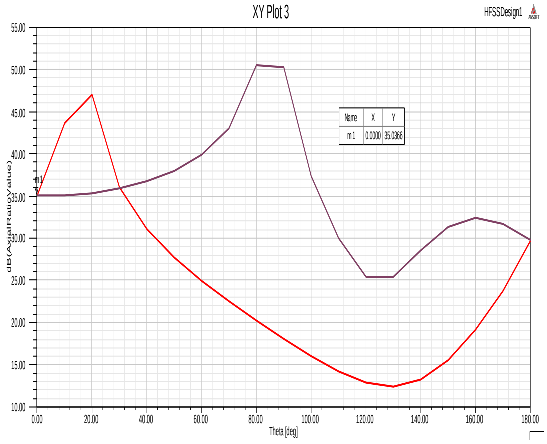

Fig. 6 Axial ratio of simple hexagonal patch

The dual frequency circular polarized hexagonal patch is found to resonate at 9.05 GHz and 10.05 GHz with return losses of -12.65 dB and -17.82 dB respectively.

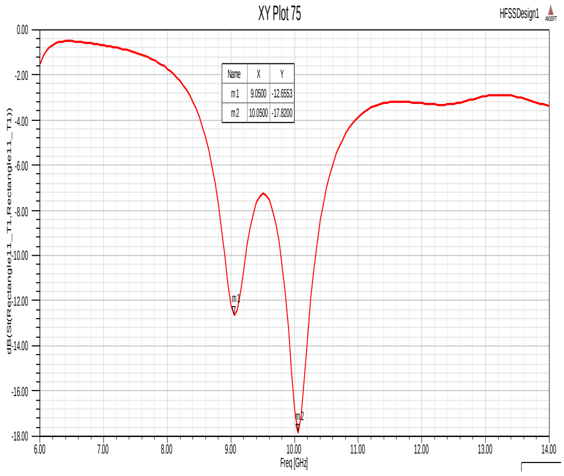

Fig. 7 Return loss of dual frequency circular polarized patch

The axial ratio in dB observed against theta values is found to be 2.85 dB which is below 3 dB. Thus the hexagonal patch is said to exhibit circular polarization.

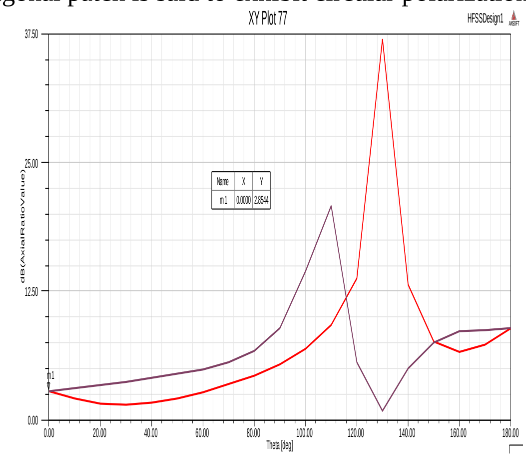

Fig. 8 Axial ratio of dual frequency circular polarized patch

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IV. CONCLUSION

The simple hexagonal patch antenna without any slots operates at 9.5 GHz and from the dB axial ratio, it has a linear polarization. The slot cut in the hexagonal patch is responsible for dual band performance while the inclination of slot and taking it to the edge lead to circular polarization.

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