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A Dual Band Circularly Polarized Slotted Square Patch Antenna

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ABSTRACT: In this paper, a probe feed low profile circularly polarized patch antenna has been proposed for microwave communication in S-band and C-band. For dual band operation, four slots are etched near edges of the patch and a cross slot has been etched in the center for generating circular polarization. The proposed antenna offers -10.53dB and -20.37 dB reflection co-coefficient at 2.27GHz and 5.42 GHz respectively which are in good agreement. It also offers 24% and 9.35% antenna efficiency at 2.27 GHz and 5.42 GHz respectively.

KEYWORDS: Dual Band, Circularly Polarized, Microwave Communication, Square Patch etc.

I.INTRODUCTION

A microstrip patch antenna consists of a very thin metallic patch placed above a conducting ground plane, separated by a dielectric substrate. Microstrip antennas have numerous advantages, they are light weight, they can be designed to operate over a large range of frequencies (1- 40 GHz.), they can easily be combined to form linear or planar arrays, and they can generate linear, dual, and circular polarizations. These antennas are inexpensive to fabricate using printed circuit board etching, which makes them very useful for integrated active antennas in which circuit functions are integrated with the antenna to produce compact transceivers. Microstrip antennas can be in various shapes and configurations. Often microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photoetched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular, or any other configuration.

A circularly polarized antenna can receive signals in all planes. Circular polarization can be obtained if two orthogonal modes are excited with a 90 degree time-phase difference. In a microstrip patch antenna, this can accomplished by adjusting the physical dimensions of the patch and using either single, or two or more feeds. In this paper, a circularly polarized antenna has been designed by cutting a rectangular slot at the centre of a square patch. Microstrip patch antennas have been widely used in circular polarization (CP) applications due to their low profile, low weight and useful radiation characteristics. In the last decade, the development of modern wireless systems has prompted increased investigation on microstrip dual-band CP antennas [1], [2], [3].

The rapid growth of satellite communication has stimulated intensive research concerning medium and high gain planar antennas. The proposed square patch microstrip antennas are formed by inserting four rectangular slots at the patch edges of a square patch. Dual frequency operation of the slot loaded patch antenna was investigated in . When narrow slots are etched close to the radiating edges, the TM10 mode is perturbed a little, whereas significant perturbation occurs for TM30 mode. Because perturbed TM300 mode has a radiation pattern similar to that of TM100 mode, the excitement of the two modes results in the dual band operation of the antenna. However the proposed antenna offers multi-band resonant frequencies.

It is preferable to use dual-frequency antenna for up and downlink to reduce size in satellite communication [4]. In addition, the transmission wave can be circularly polarized to eliminate the effects that craft rotation could have on a linearly polarized wave. Some planar structures are proposed to obtain dual-frequency circular polarization (CP) radiation of a single-feed square microstrip antenna as in [6], [7].

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II. ANTENNA DESIGN

Figure 1 shows the basic structure of a dual band slotted patch antenna. For dual band operation, the square patch must have four rectangular slots at the edges and a crossed slot has been cut at the center to produce circular polarization [8], [9], [10], [11] . Dimension of rectangular slots at the edges are15x5 mm^2. In the crossed slot, each slot is of 9x 0.7mm^2. The overall dimension of the square patch is 28X28 mm^2. To calculate these dimensions following formulae [12] have been used:

For square patch antenna,

$$L = W = \frac{0.49 * \lambda}{\sqrt{\varepsilon}} \dots\dots\dots\dots\dots (1)$$

Where,
ε = dielectric constant of the substrate
For central slot:

$$\text{Length of the slot, } c = \frac{L}{2.72} = \frac{W}{2.72} \dots\dots\dots\dots\dots\dots (2)$$

$$\text{Width of the slot, } d = \frac{L}{27.2} = \frac{W}{27.2} \dots\dots\dots\dots\dots\dots\dots (3)$$

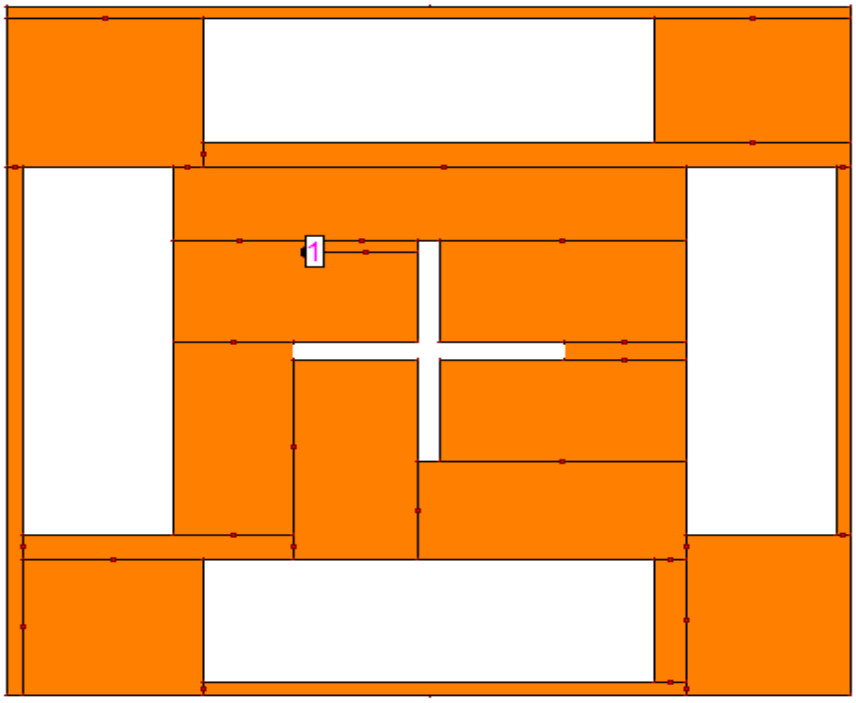

Fig. 1: Geometry of proposed antenna

For the proposed antenna, FR4 material has been used which have dielectric constant of 4.4 and thickness 1.6 mm. To feed the antenna probe feeding technique has been used. For the simulation purpose IE3D software has been used.

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III. RESULT AND DISCUSSION

Fig. 2, 3 and 4 shows the simulated result of the antenna which are in good agreement. In fig.1 reflection loss vs. frequency has been shown. From fig. 1, it is clear that at 2.27GHz and 5.42 GHz, the proposed antenna offers -10.53 dB and -20.37 dB reflection loss respectively which are good results. Fig. 3 shows antenna efficiency vs. frequency plot. From the figure, it is clear that the antenna offers 28.57% and 17.48% antenna efficiency at 2.33 GHz and 5.72 GHz respectively which satisfied the dual band characteristics. However, at 4.88 GHz and 5.18 GHz the antenna has comparatively low efficiency. Fig. 4 shows the 3-dimensional radiation pattern of the antenna.

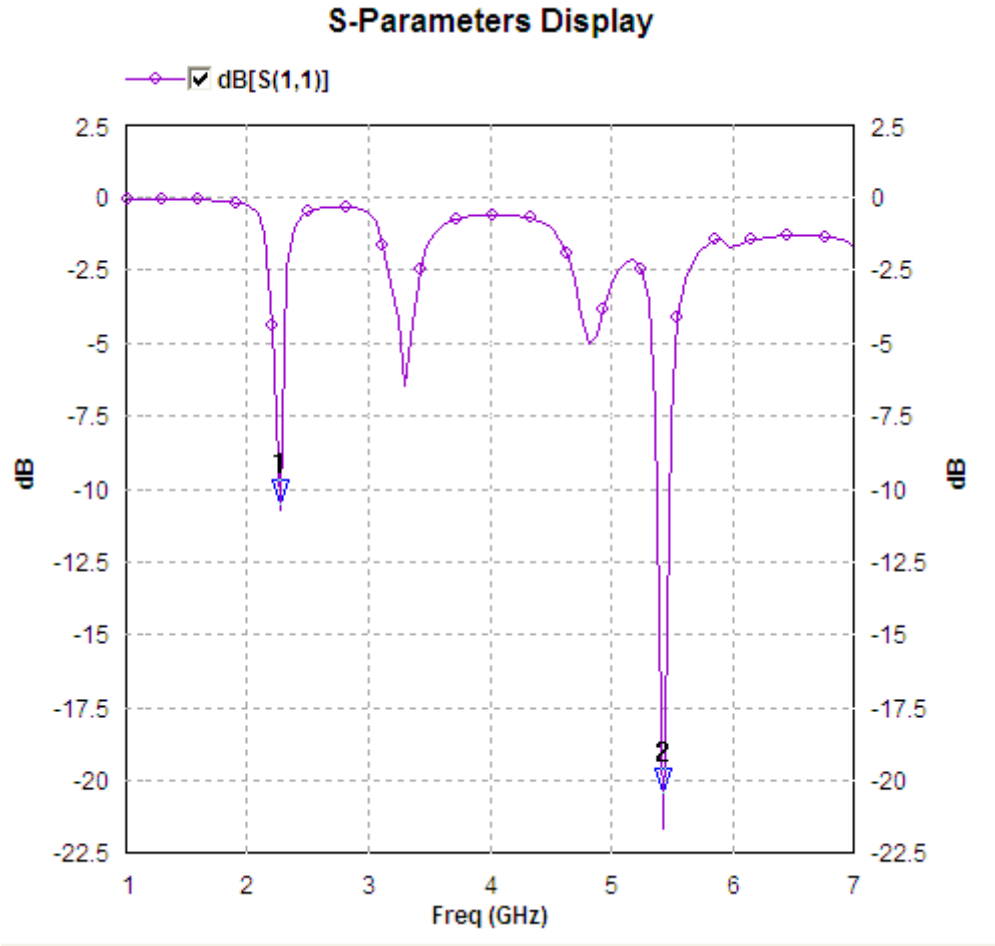

Fig.2: Reflection Co-efficient (dB) Vs. Frequency (GHz) plot

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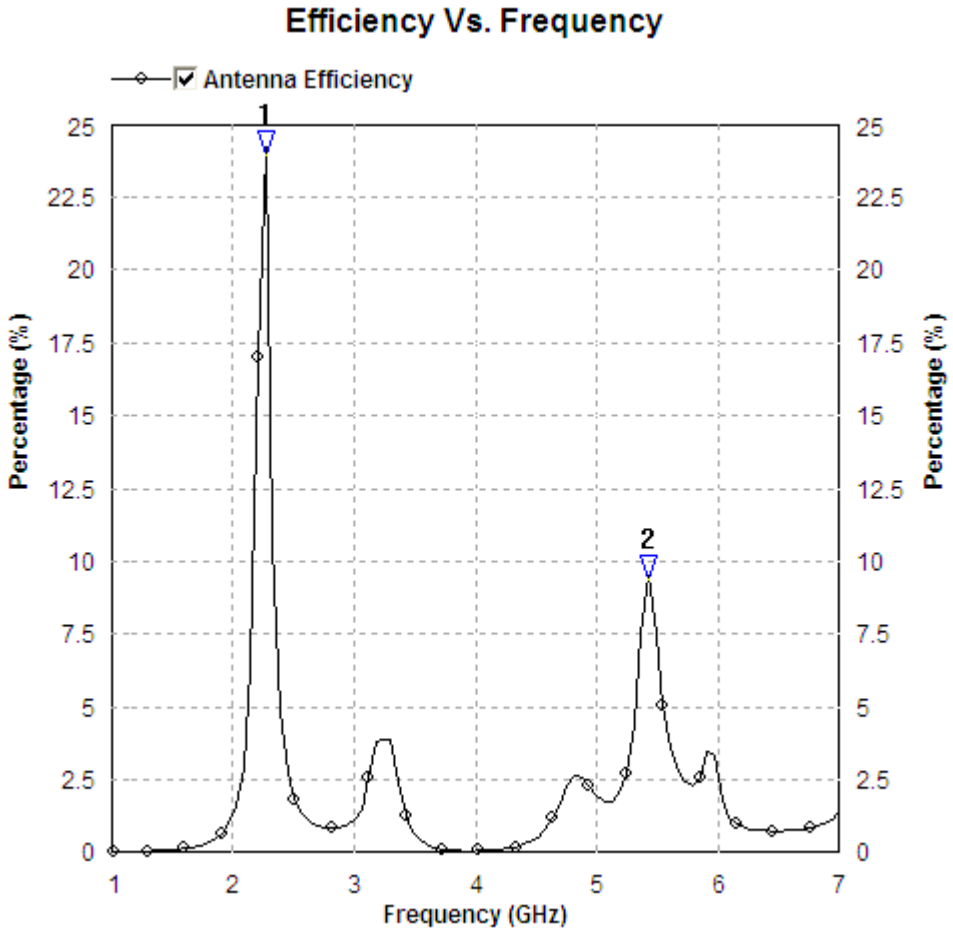

Fig.3: Antenna Efficiency (%) Vs. Frequency (GHz) Plot

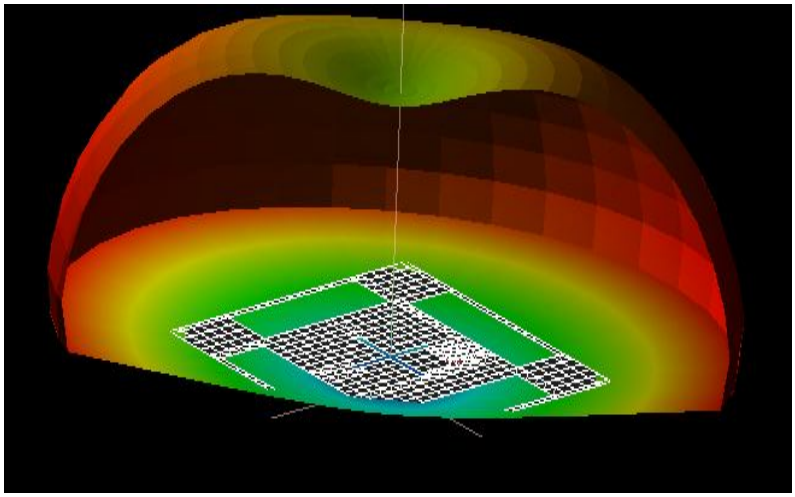

Fig.4: Radiation Pattern of the antenna

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IV.CONCLUSION

A multi-band circularly polarized square patch antenna has been designed which offers -10.53 dB and -20.37 dB reflection co-efficient at 2.27 GHz and 5.42 GHz respectively which are good results. It also offers 24% and 9.35% antenna efficiency at 2.27 GHz and 5.42 GHz respectively. This antenna can be used for microwave communication in S-band and C-band.

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