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A Multi-Band Circularly Polarized 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 single slot etched in the center for generating right handed circular polarization. However the proposed antenna offers multi-band resonant frequencies. The proposed antenna offers -14 dB, -10.76 dB, -20.02 dB and -17.81 dB reflection co-coefficient at 2.33GHz, 4.88 GHz, 5.18 GHz and 5.72 GHz respectively which are in good agreement. It also offers 28.57% and 17.48% antenna efficiency at 2.33 GHz and 5.72 GHz respectively.

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

I.INTRODUCTION

In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications that have similar specifications. To meet these requirements, microstrip antennas can be used. These antennas are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarization, pattern, and impedance. In addition, by adding loads between the patch and the ground plane, such as pins and varactor diodes, adaptive elements with variable resonant frequency, impedance, polarization, and pattern can be designed.

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

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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].

II. ANTENNA DESIGN

Figure 1 shows the basic structure of a dual band slotted patch antenna. For producing circular polarization, the square patch must have four rectangular slots at the edges and a rectangular slot has been cut at the center [8], [9], [10], [11]. Dimension of rectangular slots at the edges are14x5 mm^2. The center slot is of 10x 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:

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

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

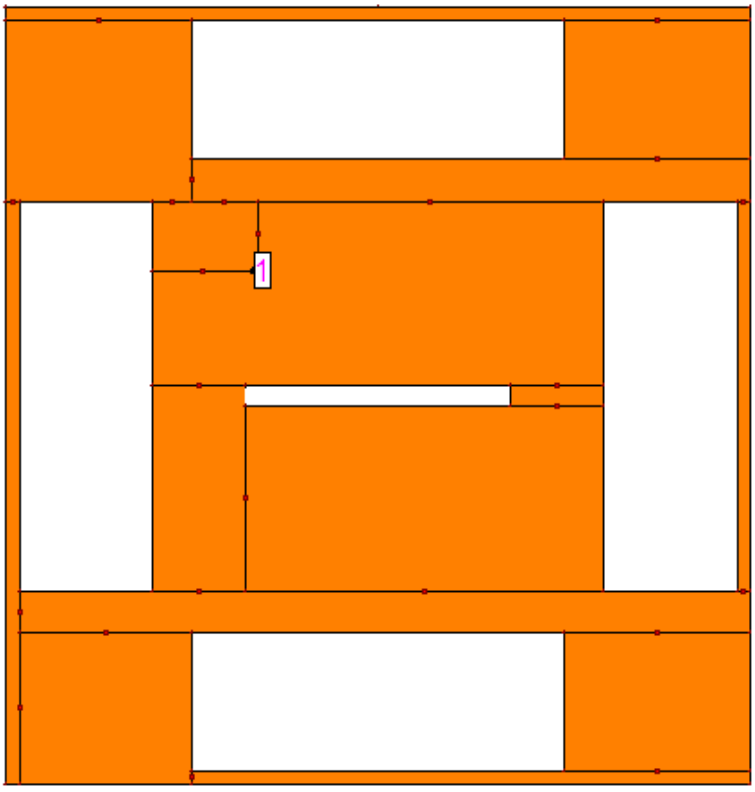

Fig. 1: Geometry of proposed antenna

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 ANDS 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 2.33GHz, 4.88 GHz, 5.18 GHz and 5.72 GHz, the proposed antenna offers -14 dB, -10.76 dB, -20.02 dB and -17.81 dB reflection loss respectively which are good results. The basic structure of the antenna is to offer dual band but the designed antenna provides four resonant frequencies which is advantageous.

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.

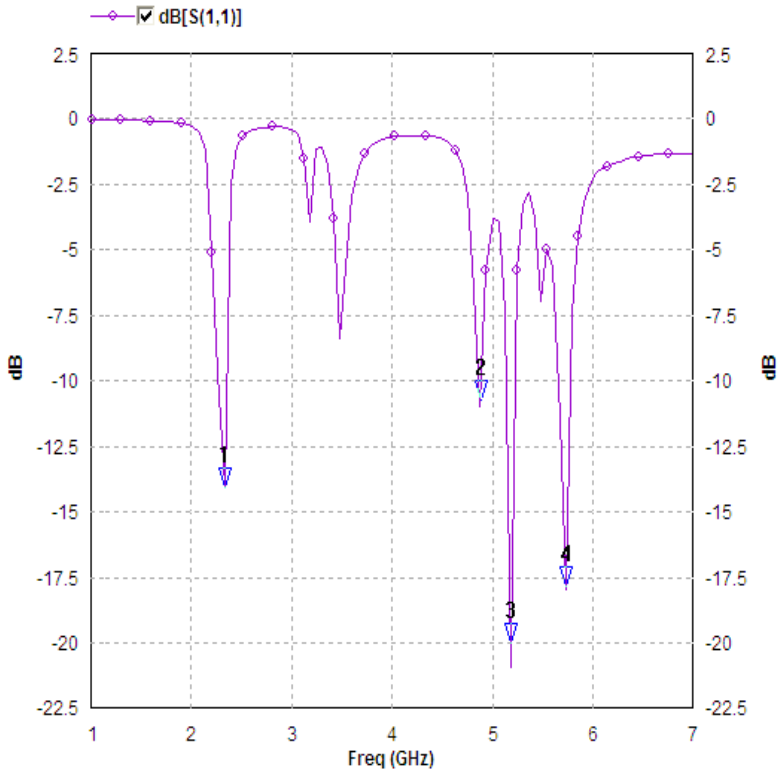

Fig.2: Reflection Co-efficient (dB) Vs. Frequency (GHz) plot

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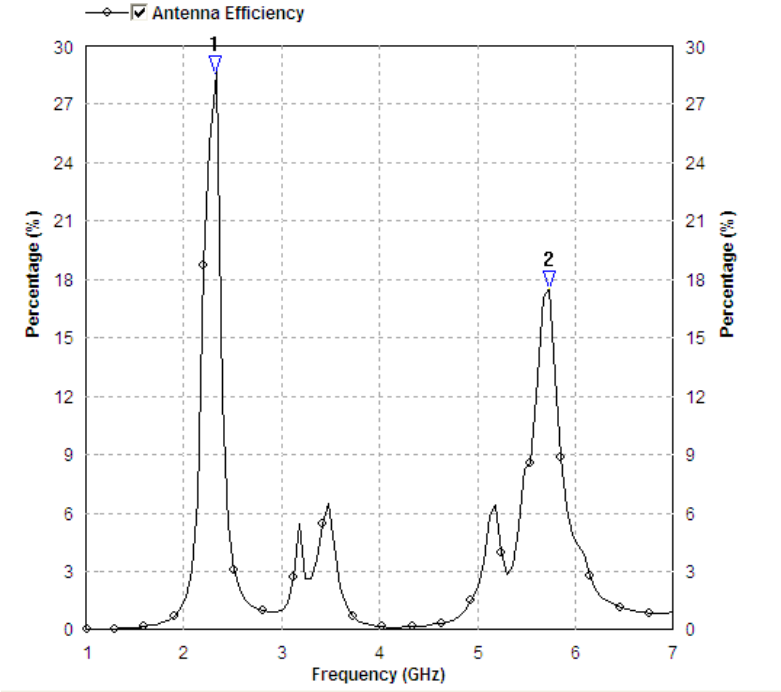

Fig.3: Antenna Efficiency (%) Vs. Frequency (GHz) Plot

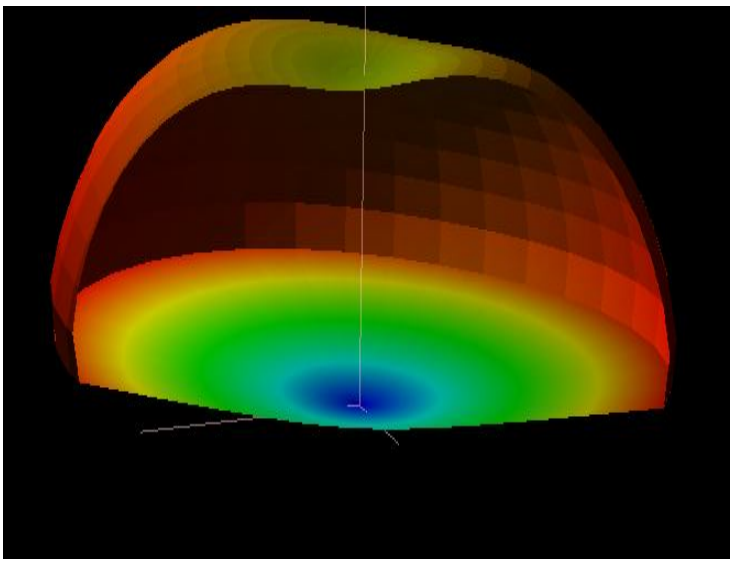

Fig.4: Radiation Pattern of the antenna

IV. CONCLUSION

A multi-band right handed circularly polarized square patch antenna has been designed which offers -14 dB, -10.76 dB, -20.02 dB and -17.81 dB reflection co-efficient at 2.33GHz, 4.88 GHz, 5.18 GHz and 5.72 GHz respectively which are good results. It also offers 28.57% and 17.48% antenna efficiency at 2.33 GHz and 5.72 GHz respectively. This antenna can be used for microwave communication in S-band and C-band.

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