Tri-band Circularly Polarized 3-Layer Stacked Patch Antenna

V. Anitha, S. Sri Jaya Lakshmi, M. L. S. N. S. Lakshmi, Y. Dhatri Sai, M. Aditya, Ch. Ravi Teja

Abstract:- ***A probe-fed circularly polarized 3-layer stacked patch antenna is presented and simulated by using Commercial Ansoft High Frequency Structure Simulator. The design consists of three patches and three substrates. The lower and middle patches are of square-shaped where as the upper patch is of triangular-shaped. One slot is inserted in the lower layer, two slots are inserted in the middle layer and three slots are inserted on the upper layer so that bandwidth can be improved. Return loss, VSWR, gain, axial ratio and radiation patterns are simulated and analyzed. This antenna is best suitable for C-band applications.***

Keywords:- Circular polarization, Stacked patch antennas.

I. INTRODUCTION

In wireless communication applications microstrip patch antennas have attracted much interest due to their compactness and multi-band operation. They are inexpensive to fabricate, light in weight, and can be made conformable with planar and nonplanar surfaces. Unfortunately, they suffer with the drawbacks, including low gain, narrow bandwidth, and sensitivity to fabrication errors [1-2]. Now-a-days, the size of these microstrip antennas should be as small as possible without compromising on their performance. Various shapes of slots and slits have been embedded on patch antennas to reduce their size [3-5]. The bandwidth of the microstrip patch antenna increases with an increase in substrate thickness and decrease in the dielectric constant also, the bandwidth increases by using stacked configurations [6-7]. The stacked patch arrangement is very popular, with reported bandwidths ranging from 10% to 20%. Owing to the fact that the stacked configuration enhances both the gain and bandwidth [8], this particular choice is preferred in the present work. Stacked configurations are possible with aperture coupled feeding, proximity feeding and coaxial feeding. Coaxial feeding provides good isolation between feed network and radiating elements and due to direct contact with the radiator reduces dielectric layer misalignment difficulties. In this paper, a 3-layer stacked patch antenna is presented. The substrates use Polyflon Norclad material which has a dielectric constant of $\varepsilon_r = 2.55$ and a height of 1.5 mm. The slots are inserted on the patches in the increasing order (from lower layer to upper layer). It resonates at three frequency bands and is suitable for C-band applications.

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II. ANTENNA DESIGN

Figure 1 shows the geometry of the patches. The lower layer consists of a square-shaped patch with 1 slot on it. The dimensions of the patch and slot are 44 × 44 mm2 and 34 × 1 mm2 respectively. The middle layer consists of a square-shaped patch with 2 slots on it. The dimensions of the patch and slots are 41.4 × 41.4 mm2 and 34 × 1 mm2 respectively. The upper layer consists of a triangular-shaped patch with 3 slots on it. The triangular-shaped patch has a base of 34 mm and a height of 34 mm. On the upper patch three slots of different lengths are considered. The dimensions of the 3 slots are 24 cm, 18 cm, 8 cm lengths and 1 cm width each respectively. The location of the feed is (5, 5). Coaxial probe is used for good excitation of antenna over entire range. Figure 2 shows the proposed antenna model which consists of three stack layers.

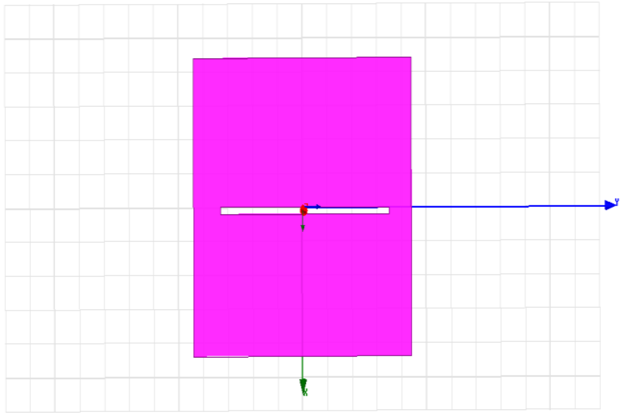

Fig 1 (a): Geometry of the lower layer patch

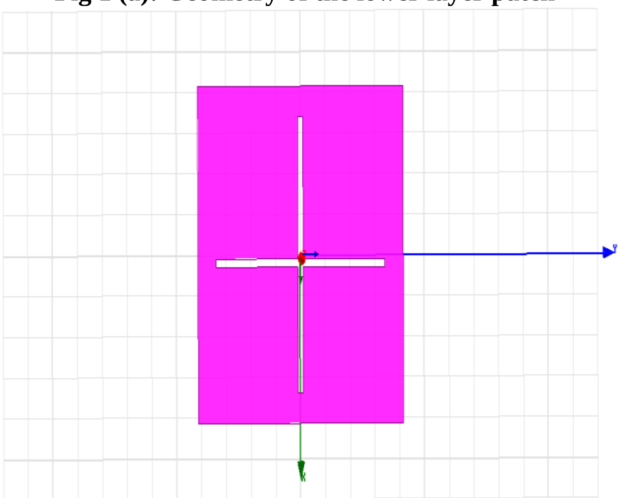

Fig 1 (b): Geometry of the middle layer patch

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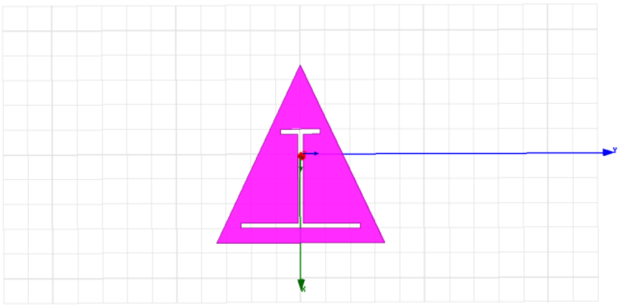

Fig 1 (c): Geometry of the upper layer patch

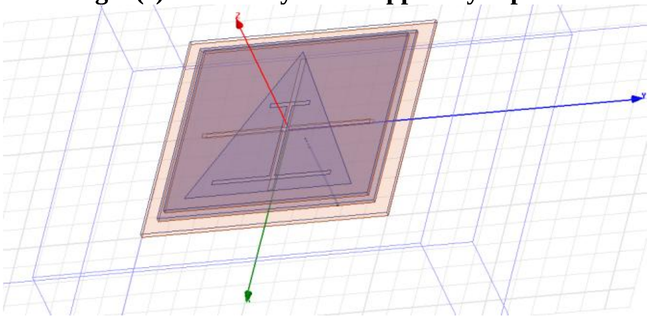

Fig 2: Proposed Stacked antenna model

The proposed antenna uses Polyflon Norclad substrate which has a dielectric constant εr = 2.55 and a height of 1.5 mm. Circular polarization can be achieved using a single probe feed along the direction 450 to the centerlines of the patch. With this antenna, broad bandwidth and relative gain improvement has been achieved. A parametric study and an optimization are done, in order to find the best feeding point of the structure. Several points are tested in order to get an overview of the defined functioning of the antenna. At first, the feeding is chosen far away from the radiating elements, which results the non-functioning of the antenna. Second, the feeding point is moved close to the radiating elements in order to obtain optimum operation of the antenna.

III. RESULTS AND ANALYSIS

A. Return Losses

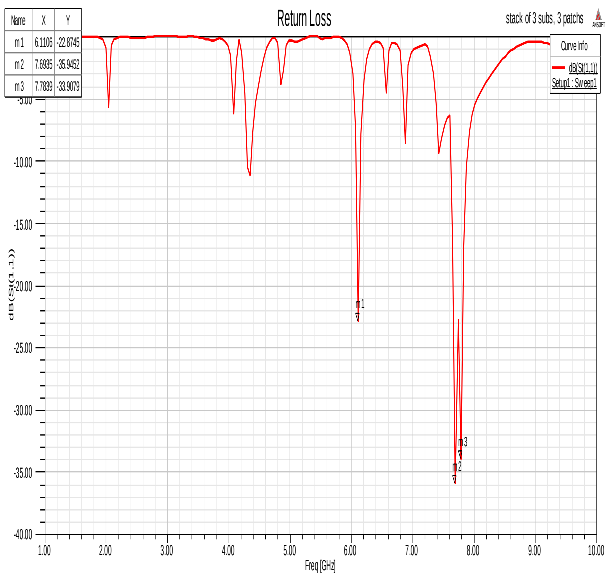

Fig 3: Return losses

From Figure 3, the return losses of the proposed antenna at 6.11 GHz, 7.69 GHz and 7.78 GHz are -22.87 dB, -35.94 dB and -33.90 dB respectively. This is showing excellent value of return loss < -10 dB at the three frequencies.

B. VSWR

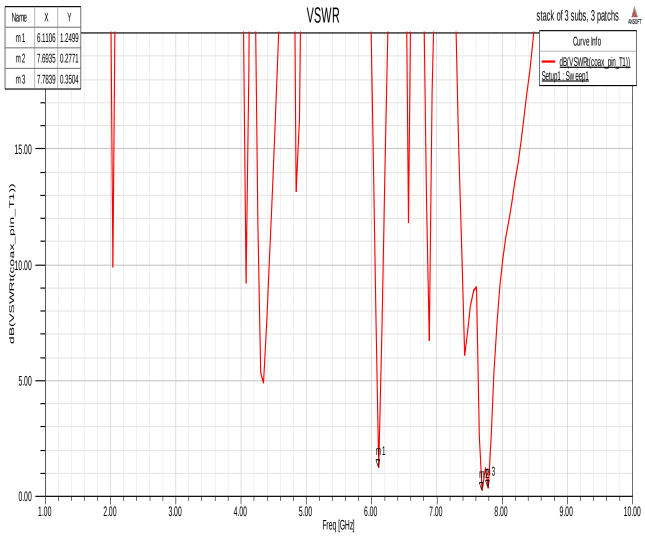

Fig 4: VSWR

At all operating frequencies, the value of VSWR is less than 2. From figure 4, the VSWRs at 6.11 GHz, 7.69 GHz and 7.78 GHz are 1.24 dB, 0.27 dB and 0.35 dB respectively. A low value of VSWR implies the antenna is well-matched.

C. Gain

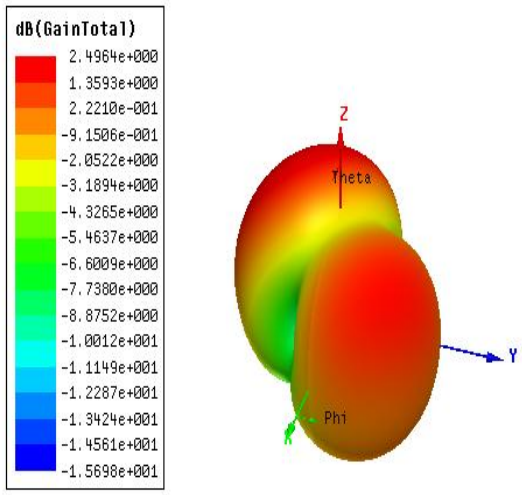

Fig 5: 3D- Gain Total

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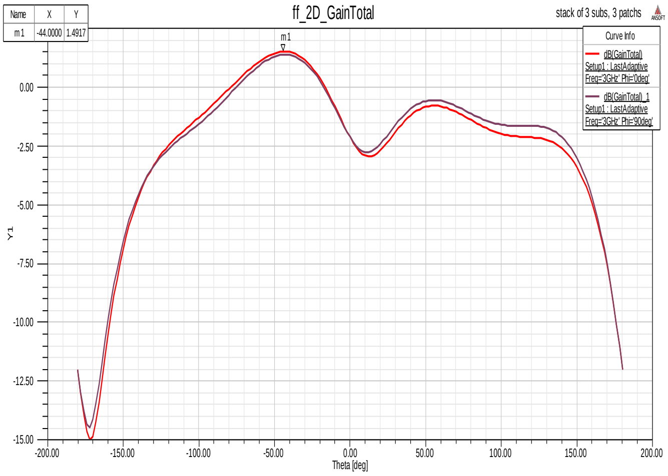

Fig 6: 2D- Gain Total

Figures (5-6) shows the gain of the antenna in 3D and 2D patterns. The gain of the proposed stack antenna is 2.49 dB.

D. Radiation Patterns

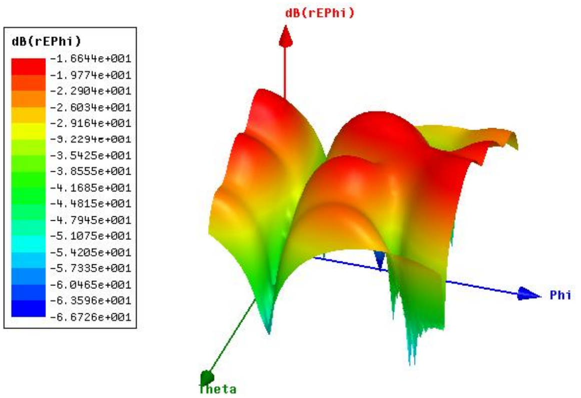

Fig 7: Radiation pattern in Phi direction

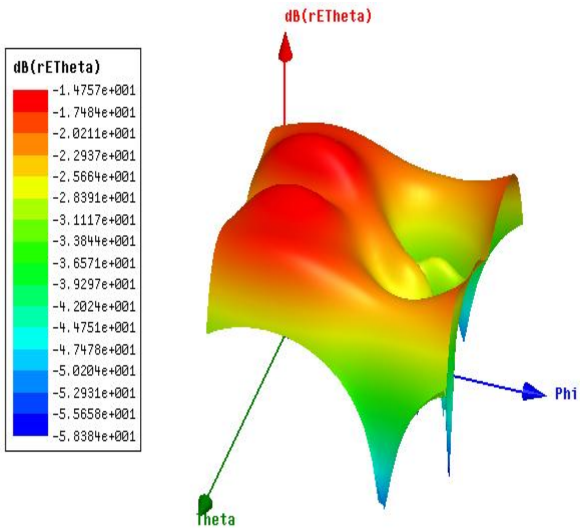

Fig 8: Radiation pattern in Theta direction

The radiation of the antenna is expressed in terms of the field strength E (in V/m), and then the graphical representation is called field strength pattern or field radiation pattern. Figures (7-8) shows the radiation pattern of the proposed antenna.

E. LHCP and RHCP

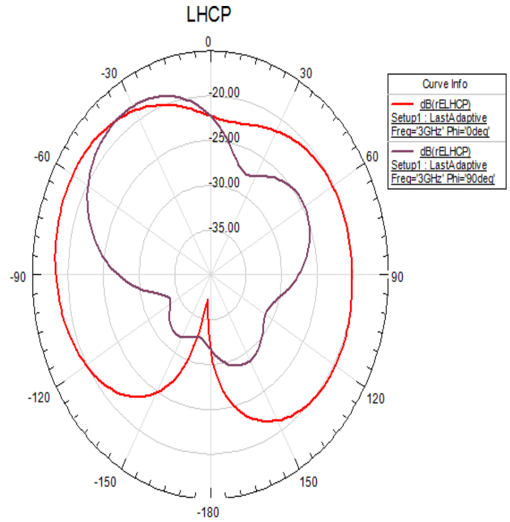

Fig 9: Left-handed Circular Polarization

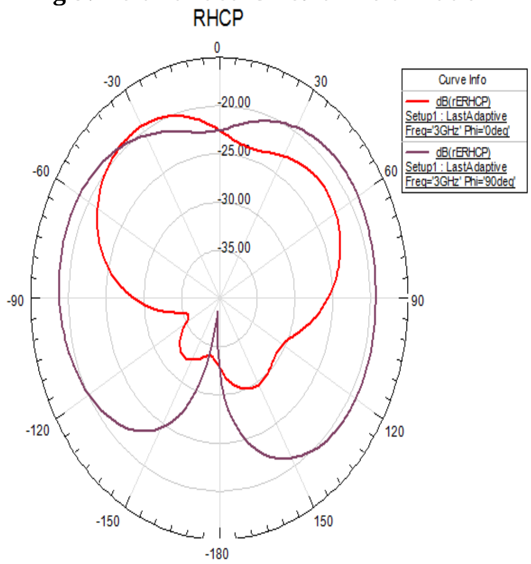

Fig 10: Right-handed Circular Polarization

To have circular polarization, the following criteria must be met:

- The E-field must have two orthogonal (perpendicular) components.
- The E-field's orthogonal components have equal amplitude.
- The orthogonal components must be 90^0 out of phase.

If the fields are rotating in counter-clockwise direction, it is said to be Right Hand Circularly Polarized (RHCP). If the fields are rotating in clockwise direction, it is said to be Left hand Circularly Polarized (LHCP). Figures (9-10) shows the LHCP and RHCP of the proposed antenna.

F. Axial Ratio

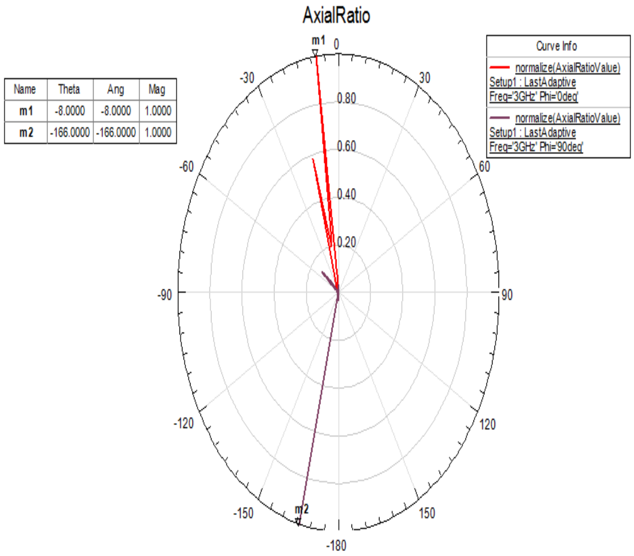

Fig 11: Axial Ratio

Axial ratio is the ratio of the major axis to minor axis of the polarization ellipse. For circular polarization, the ratio of major axis to the minor axis ais 1. Therefore, the axial ratio for circular polarization is 1. The ideal value of the axial ratio for circularly polarized fields is 0 dB. Axial ratios are often quoted for antennas in which the desired polarization is circular. Figure 11 shows the axial ratio for the proposed antenna.

IV. CONCLUSION

A tri-band circularly polarized 3-layer stacked patch antenna of operating frequencies in the range (6-8) GHz is proposed. The CP radiations are achieved by inserting the slots in the increasing order from the lower layer to the upper layer. The feed locations are optimally chosen to give as many resonant frequencies as possible. By placing three layers, the number of resonance frequencies is increased. The proposed antenna operates at three frequencies 6.11 GHz, 7.69 GHz and 7.78 GHz, therefore it is suitable for C-band applications.

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