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Circularly Polarized Slotted Microstrip Patch Antenna with Finite Ground Plane

Sanyog Rawat*, K K Sharma**

* Amity School of Engineering and Technology, Amity University Rajasthan, Jaipur, India

** Malaviya National Institute of Technology, Jaipur, India

ABSTRAKSI

Dalam makalah ini geometri baru patch antena polarisasi sirkular diusulkan dengan peningkatan bandwidth. Kinerja radiasi antena patch yang diusulkan diselidiki dengan software simulasi IE3D dan kinerjanya dibandingkan dengan antena patch persegi panjang konvensional. Return loss simulasi, rasio aksial dan impedansi dengan frekuensi untuk antena diusulkan dilaporkan dalam makalah ini. Hal ini menunjukkan bahwa dengan memilih yang sesuai dimensi bidang persegi, celah udara dan lokasi dari slot, bandwidth impedansi dapat ditingkatkan sampai 10,15% dibandingkan dengan patch persegi panjang konvensional (4,24%) dengan bandwidth yang rasio aksial 4.05%.

Kata Kunci: Microstrip Patch, Polarisasi Sirkular, Bandwidth, Rasio Axial

ABSTRACT

In this paper a new geometry of circularly polarized patch antenna is proposed with improved bandwidth. The radiation performance of proposed patch antenna is investigated using IE3D simulation software and its performance is compared with that of conventional rectangular patch antenna. The simulated return loss, axial ratio and impedance with frequency for the proposed antenna are reported in this paper. It is shown that by selecting suitable ground-plane dimensions, air gap and location of the slots, the impedance bandwidth can be enhanced upto 10.15% as compared to conventional rectangular patch (4.24%) with an axial ratio bandwidth of 4.05%.

Keywords: Microstrip Patch, Circular Polarization, Bandwidth, Axial Ratio

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1. INTRODUCTION

Microstrip antennas have become increasingly popular for microwave and millimeter wave applications, because they offer several advantages over conventional microwave antennas. These advantages include robust structure, easy to fabricate, small size, availability in various shapes, lightweight and conformability with the hosting surfaces of automobiles, aircraft, missiles and direct integration with the microelectronics [1] [2]. Microstrip antenna consists of radiating conducting patch, conducting ground plane, dielectric substrate sandwiched between the two and a feed connected to the patch through the substrate [3]. The miniaturizations in electronic designs have generated tremendous demand for compact and efficient antenna geometries. However, these types of antennas have several limitations like low gain, impurity in polarization, poor bandwidth and low radiation efficiency which cannot be ignored [4]. Among the conventional patch geometry rectangular and circular patches are widely used because they are easy to design and analyze.

Usually the requirement for a compact antenna is associated with a reduction in ground plane size to the extent that antenna performance becomes strongly dependent on the ground plane dimensions and position. It is already investigated in past that the grounded dielectric supports a finite number of surface wave modes (SWMs) which propagate in a direction parallel to the air-dielectric interface [5]. The effects of change in finite ground plane dimensions on antenna impedance have been investigated and several techniques to enhance bandwidth and achieve dual polarization is reported [6] [7]. The effect of different shapes of ground structure on polarization and cross polarization radiation is also investigated in past [8][9].

In this communication, we present novel patch antenna geometry for achieving circular polarization and improvement in bandwidth by using finite ground plane and additions of slots in patch geometry. We have used Method of Moments (MOM) for the analysis of proposed antenna although some other methods such as Transmission line Model, Cavity Model, Spectral Domain Full Wave Analysis, Mixed Potential Integral Equation Analysis, Finite-Difference Time-Domain Analysis (FDTD), Finite Element Method (FEM) etc. exist. Results show that by selecting suitable ground-plane dimensions and location of slots, the impedance bandwidth can be enhanced upto 10.15% and axial ratio bandwidth of 4.05% can be achieved.

The rest of the paper is organized as follows. In section II the proposed antenna geometry is discussed. Simulation results have been discussed in section III. The conclusions are given in section IV.

2. PROPOSED ANTENNA GEOMETRY

Patch antennas having rectangular, circular or their minor variations, are generally used. A conventional rectangular patch shown in fig. 1 is modified by introduction of slots along the edges and at the center of the patch. An air stacking of 0.8mm is also added between two substrate layers, sandwiched between patch and ground plane, as shown in fig. 2(a) and (b). Here conventional rectangular patch antenna is considered the reference antenna to compare the results of proposed geometry.

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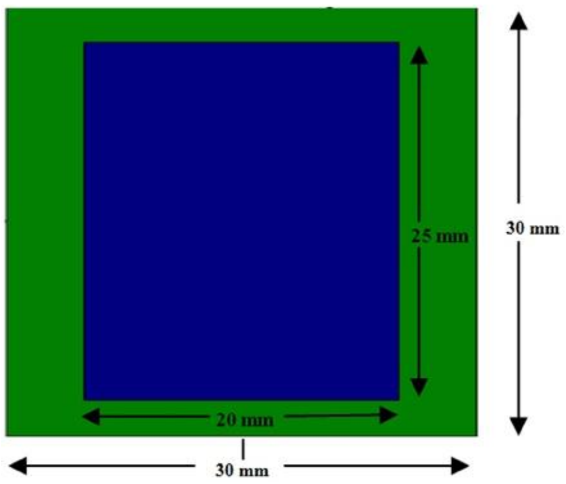

Figure 1. Conventional rectangular microstrip patch antenna

The conventional rectangular patch has dimensions as 20×25mm and finite ground dimension as 30×30mm. A 50Ω coaxial probe is used to connect the microstrip patch at coordinates and it is made fixed for both the conventional and proposed geometry.

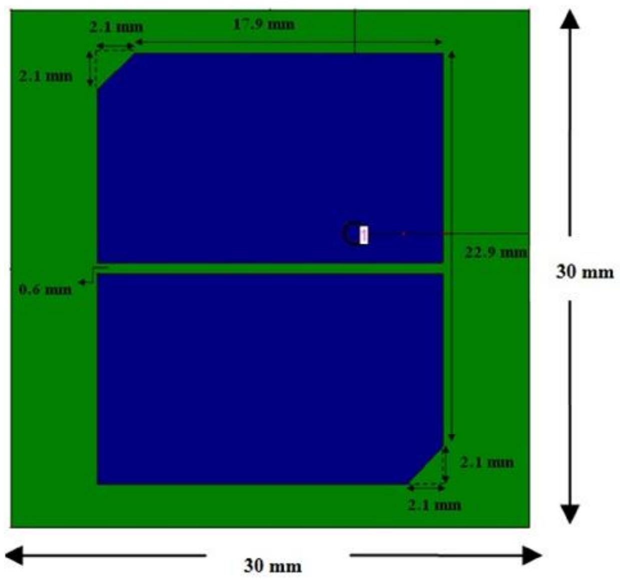

Figure 2(a). Top view of proposed antenna geometry

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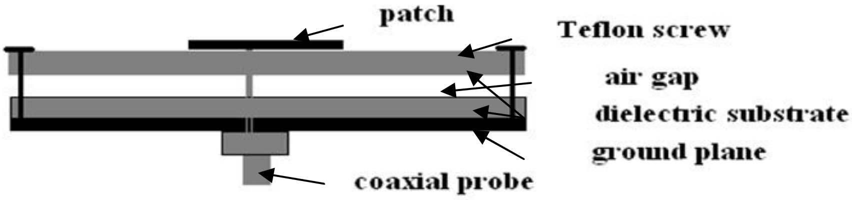

Figure 2(b). Side view of the proposed geometry with coaxial feed

The proposed geometry is obtained by cutting edges of dimensions 2.1×2.1mm at the two diagonal corner of patch with 45^0 degree elevation as shown in figure 2(b). A slot of L=20mm and W=0.6mm is also introduced at the center of the patch and finite ground plane has dimensions of 30×30mm. The proposed geometry is designed on glass epoxy FR4 substrate having thickness h=1.59mm, substrate dielectric constant ε_r=4.4, substrate loss tangent $\tan\delta$= 0.024, and relative permeability μ_r=1 with an air-gap of 0.8mm. Circular polarization with simple topology and improvement in the other antenna radiation parameters are the main advantages of this geometry. Many simulations are done for optimizing the length, width and location of the slots and best results are obtained with defined length and width of the slot. Due to existence of the slot, the current distribution changes and another mode is excited. Each mode has its own cut-off frequency and thus the proposed geometry has a new resonant frequency which is different from the conventional patch resonant frequency.

3. RESULTS AND ANALYSIS

The simulation results of conventional rectangular patch and proposed geometry are obtained using IE3D Software [10].

3.1. Results of Conventional and Proposed Geometry

Radiation Pattern: A plot through which it is visualized where the antenna transmits or receives power. The microstrip antenna radiates normal to its patch surface. So, the elevation pattern for $\varphi= 0^0$ and $\varphi= 90^0$ are important for the simulation.

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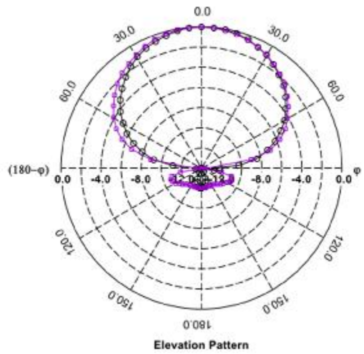

Figure 3. Computed elevation pattern for the conventional geometry

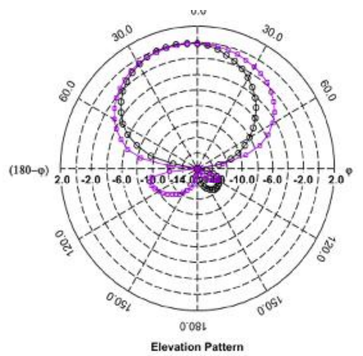

Figure 4. Computed elevation pattern for the proposed geometry

The simulated E-plane patterns i.e. the two dimensional pattern-view of the geometries is illustrated in fig. 3 and 4. Radiation patterns are found to be smooth and uniform over the band of frequencies for both the geometries.

Return Loss and Bandwidth: Return Loss is a measure of how much power is delivered from the source to a load and is measured by S_{11} parameters. The range of frequencies over which the antenna can operate effectively is characterized by bandwidth. It can be calculated by going 10dB down in return loss.

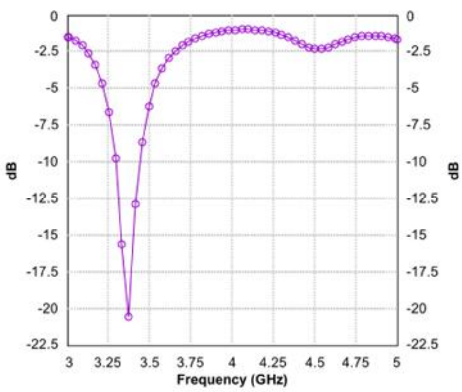

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Figure 5. Computed variation of return loss with frequency for conventional geometry

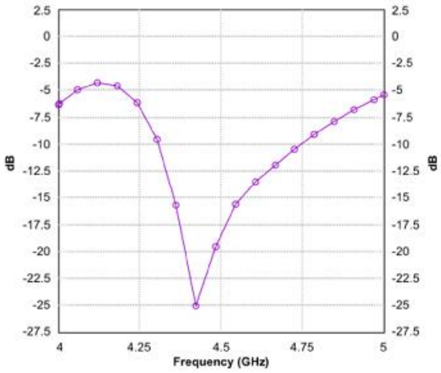

Figure 6. Computed variation of return loss with frequency for proposed geometry

The variation of return loss with frequency is shown in fig. 5 and 6. The conventional rectangular patch antenna resonates at frequency of 3.37 GHz with -20.85dB return loss and the impedance bandwidth obtained is 4.24%. The proposed patch antenna has -25.12dB return loss at resonating frequency of 4.42 GHz and the impedance bandwidth obtained is 10.15%.

Smith Chart*:* Smith Chart provides the information about the polarization and the impedance-matching of the radiating patch.

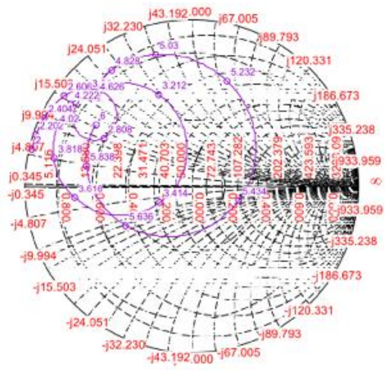

Figure 7. Variation of input impedance with frequency for conventional geometry

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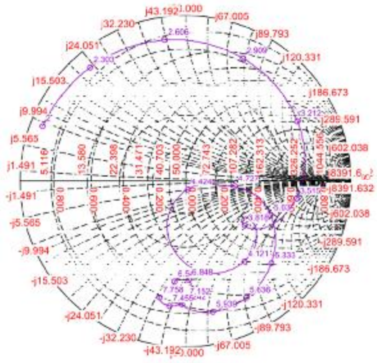

Figure 8. Variation of input impedance with frequency for proposed geometry

Simulated input impedance variation with frequency is shown in fig. 7 and 8. The circle passes through the centre of the smith chart represents the impedance match of (41.4+j0.77)Ω for conventional patch and (51.3-j5.49)Ω for proposed geometry with the coaxial probe and it shows that proposed geometry has better impedance matching than conventional patch.

Axial Ratio*:* This is related with quality of circular polarization of an antenna and axial ratio bandwidth is obtained by calculating the range of frequencies falling between 0 dB to 3 dB.

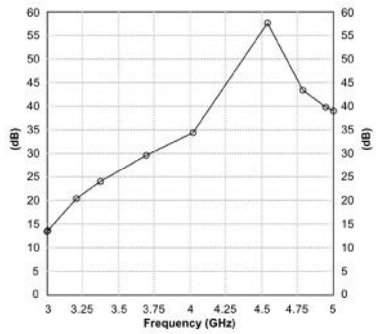

Figure 9. Variation of axial ratio with frequency for conventional geometry

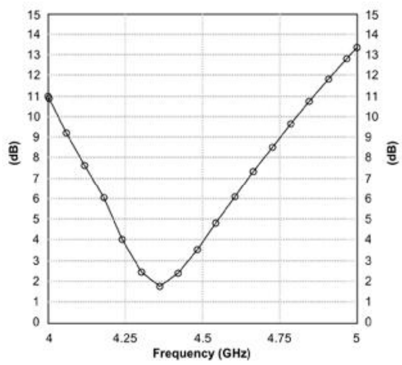

Figure 10. Variation of axial ratio with frequency for proposed geometry

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The variation of axial ratio with frequency for conventional patch antenna is shown in fig. 9 it is observed that the geometry is not circularly polarized with axial ratio of 23.97dB at resonant frequency. The axial ratio observed for the proposed geometry is shown in fig. 10, the geometry is found to be circularly polarized with axial ratio of 1.77dB at resonant frequency and axial ratio bandwidth of 4.05%.
The comparison between radiation parameters of conventional patch antenna and proposed geometry is tabulated in table 1.

Table 1. Comparison of conventional and proposed geometry

Sr. No.	Parameters	Conventional Patch	Proposed Patch
1.	Resonant Frequency (GHz)	3.37	4.42
2.	Return loss (dB)	-20.85	-25.12
3.	Bandwidth (%)	4.24	10.15
4.	Axial Ratio (dB)	23.97	1.77 (4.05% Axial-Ratio BW)

4. CONCLUSION

This paper presents the radiation performance of proposed patch antenna. The performance of proposed geometry has been compared with conventional geometry. Simulated results indicate that the antenna exhibits axial ratio bandwidth upto 4.05% by optimizing the length, width of slots and air gap in proposed antenna geometry. There is also improvement in impedance bandwidth upto 10.15%. The radiation pattern is found to be stable over the entire bandwidth. Finally, we found the proposed geometry to be circularly polarized which is a great advantage in modern communication system.

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