Patch Antenna with Triangular Slitted Corners

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***Abstract*—In this paper, a microstrip patch antenna with triangular slits was designed, simulated, fabricated and tested. The proposed patch antenna, with operating frequency of 9.5 GHz, is targeted. Simulation is carried out using Sonnet Suites. Antenna has 9.68 dB gain at 9.5 GHz with corresponding reflection coefficient of -19 dB. Proposed antenna introduces size reduction for patch antennas. The measurements of the fabricated patch antenna well corroborate the simulation results.**

Keywords*—*Asymmetric triangular slit, gain, microstrip patch antenna.

I. INTRODUCTION

Microstrip patch antennas (MPAs) have sparked tremendous research efforts with great prospects and they have been widely integrated into many wireless applications. The salient features of MPAs have made them the ultimate candidates for applications, such as space born systems, radar or satellite systems, where lightweight and cost-effective antennas with low-profile and simple geometrical structure for ease of fabrication and installation are required. With the ever-increasing need for mobile communication and the emergence of many systems, it is important to design broadband antennas to cover a wide frequency range. The design of an efficient wide band small size antenna, for recent wireless applications, is a major challenge. Microstrip patch antennas have found extensive application in wireless communication system owing to their advantages such as low profile, conformability, low-cost fabrication and ease of integration with feed networks [1].

A factor that influences the performance of an antenna is the structure of the patch. At present is a predictable necessitate for a packed in scrap aerial having a most favorable geometrical construction which is effortlessly to make and gives a towering aerial gain point. The corners were truncated square microstrip antenna is mainly used for single patch designs. In his work, Gokten obtained the compactness of the proposed circular polarization design because of inserting four slits of equal lengths at the corners [2].

A solitary nourish spherical schism procedure of the corners shortened square microstrip antenna is mainly used in single patch designs and array designs [3].

Microstrip patch antennas are usually designed to eliminate the imaginary part of the input impedance. Edge fields are also important and they bring an additional length to the antenna. This length depends on the relative permittivity of the dielectric, dielectric height and patch width [4].

A microstrip patch antenna is made up of a radiating patch on one side of dielectric substrate while has a ground plane on the other side [5]. Substrate is located over a large metallic sheet called ground plane [6]. The suitable substrate is the one with a low dielectric constant, a large thickness compared to the operating wavelength and low loss (low tan *δ)* because in the realization of microwave circuits, the goal is to minimize the radiation of the line in free space and therefore have a substrate which the electromagnetic energy is concentrated in the dielectric (more precisely in the cavity formed by the metal strip and the ground plane). So a thick substrate increases the power radiated by the antenna, reduces losses by Joule effect and improves the bandwidth of the antenna. Permittivity of substrate is a critical parameter in controlling band width, efficiency, and radiation pattern of patch antenna. However, higher dielectric constant also reduces bandwidth and radiation efficiency [7].

The Wireless communication is mainly concentrated on the antenna size. The reduced antenna size results in small sensor node and low power consumption [8]. So the antenna can be a low profile, low powered and high frequency micro strip antenna. The antenna size is proportional to $1/\sqrt{\xi r}$ [9]. Small antenna concept is the one which uses planar antenna and by adjusting the electrical size the desired center frequency can be obtained [10].

The operation frequency of the reference antenna is 2.285 GHz. The size of the antenna is 80 mm × 80 mm. The coaxial probe feeding technique is used. Reference antenna has a parasitic element strip under the main part and antenna has 4 asymmetric triangular slits [11].

In this paper, the parasitic element strip in the reference antenna was removed, the number of slits was reduced from 4 to 2 and the feed position was moved to the middle of the antenna with input impedance of about 50 Ω. The size of the antenna is reduced to 21.6 mm × 21.6 mm and simulation air thickness is 10 mm. As a result of the analysis, operation frequency is 9.5 GHz. Slits angle and feeding point were changed to optimize the maximum gain, lowest return loss and smaller antenna dimensions.

The rest of this paper is organized as follow: the design steps are described in Section II, results and conclusion are presented

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in Section III of the paper.

II. DESIGN STEPS

The geometrical shape of the triangular microstrip patch antenna with triangular slits design in the first step is as shown in Fig. 1. The size of the antenna is 43 mm × 42.5 mm and the box size is 700 mm × 700 mm. Initial design didn't achieve targeted center frequency of 9.5GHz.

In the second stage, the design in Fig. 2 was created by optimizing triangular slit measurements and determining the feed point location. So many iterations of simulation were carried out to achieve optimization. As a result of optimized simulation, S11 value was measured as -10.06 dB at 2.3 GHz and -19.56 dB at 4.7 GHz, antenna gain was measured as 4.82 dB at 2.3 GHz and 7.30 dB at 4.7 GHz. Yet, this design didn't achieve targeted center frequency of 9.5GHz as well.

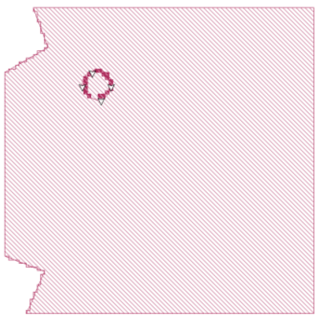

Fig. 1. First design.

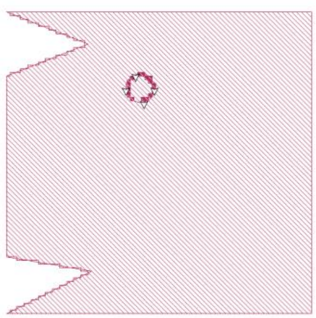

Fig. 2. Second design.

At the third step, the final design in Fig. 3 was created by reducing the antenna size and changing the feed position. The proposed patch antenna with triangular slits is designed using RT/duroit 6002 substrate with dielectric constant of 2.94, thickness *h=0.76mm* and loss tangent of 0.0012.

As a result of successive iteration of simulations, the S11 value is measured as -19.65 dB and the antenna gain is measured as 9.68 dB at 9.5 GHz, and the reverse polarity value is measured as -6.03 dB. All dimensions are provided in Fig. 3. Optimized antenna was fabricated and carried out the measurements. Fabricated antenna is shown in Fig. 4.

The S11 value obtained as a result of the final design is shown in Fig. 5. Simulation S11 is -19.65 dB but measured S11 is -11 dB. Correlation of input impedance between measured and simulation is acceptable, both in good agreement at resonant frequency. Although simulation shows -19 dB input impedance, it is difficult to achieve such input impedance from manufactured patch antenna.

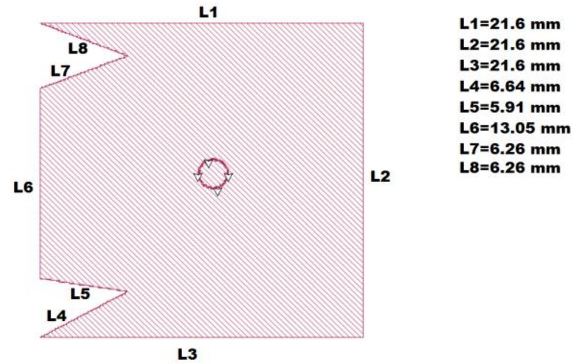

Fig. 3. Final design.

Fig. 4. Fabricated and measured antenna.

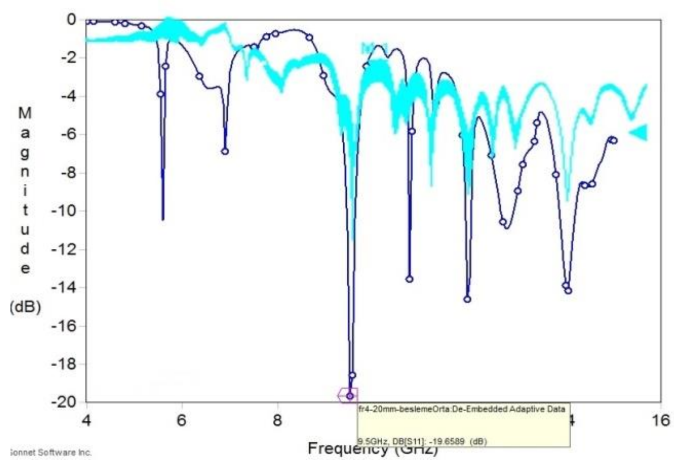

Fig. 5. Input match (|S11|) of the proposed antenna.

III. RESULTS AND CONCLUSION

A comprehensive parametric study of a triangular shaped double-slit microstrip patch antenna has been carried out to understand the effects of various triangular slits. The simulations results are performed using Sonnet software [12]. The frequency range of Sonnet simulation was between 0-15 GHz. Studied antenna resonance frequency is 9.5 GHz. As a result of studies and numerous simulations on the geometry of the slit, optimum dimensions have been determined. When results of simulations made by taking air thickness 10 mm and insulation thickness 1.6 mm, simulated and measured S11 were matched well at the resonance frequency of 9.5 GHz, where measured S11 is slightly lower than -11 dB and gain is 9.68 dB. Smaller antenna size was achieved due to triangular slits.

Gain of the antenna (E Theta - E Phi) radiation diagram occurred at resonance frequency at 9.5 GHz is given in Fig. 6. As seen in this graph, cross-polarization level is less than -7 dB and co-polarization has nice wide beamwidth.

Measurement is carried out in Yeditepe Universities testing facility. Measurement setup is shown in Fig. 7.

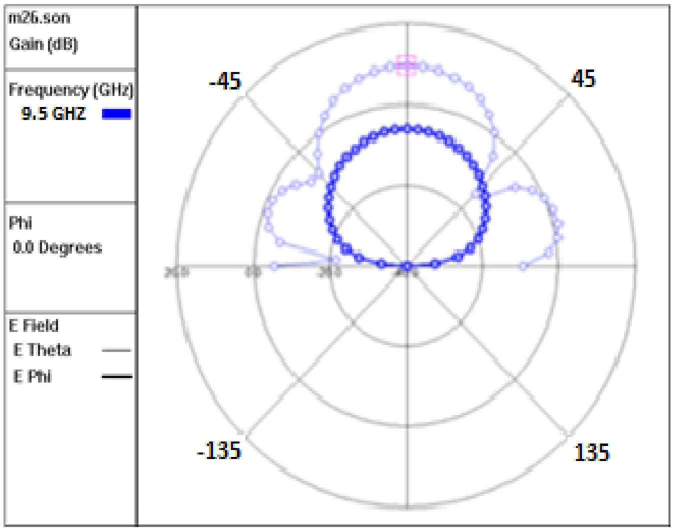

Fig. 6. E Theta – E Phi radiation pattern of patch antenna at 9.5 GHz.

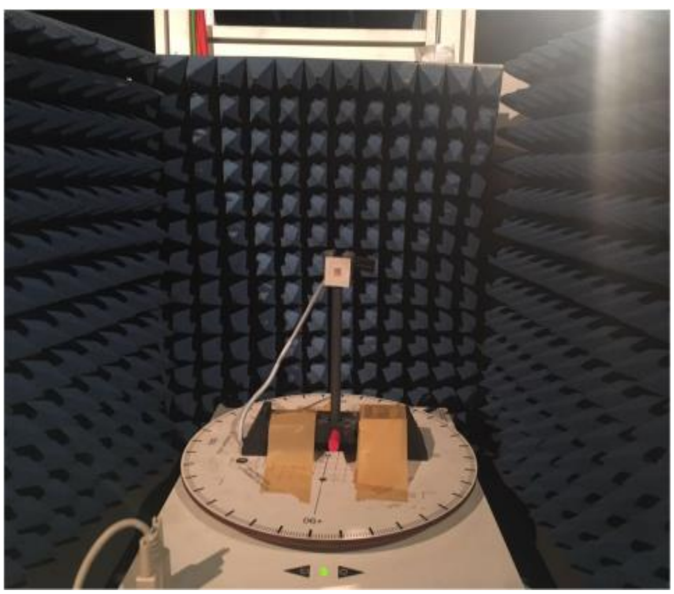

Fig. 7. Measurement setup.

The flux density at 9.5 GHz is given in Fig. 8. It is clear that current is crowded near the discontinuities of two triangular slits and around the feeding point as expected. Furthermore, color pattern shows an approximate wavelength of the antenna.

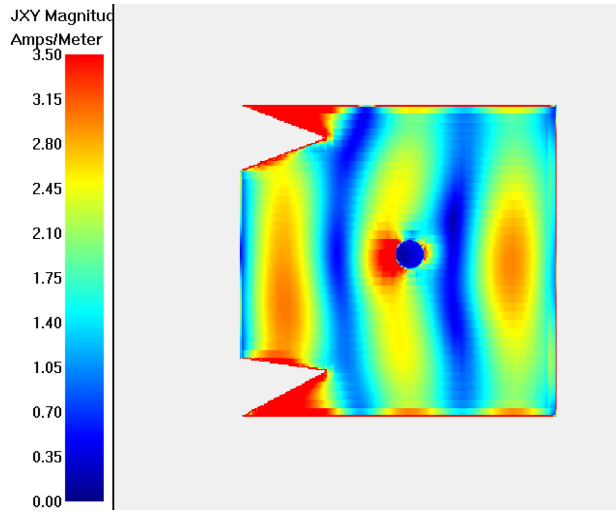

Fig. 8. The current distribution at 9.5 GHz.

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