

Design and Fabrication of Circularly Polarized Microstrip Patch Antenna using Symmetric Slit

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Abstract: Polarization is important factor for antenna in wireless communication. Polarization between transmitting and receiving antennas needs to be same for better reception of signal. Matching the polarization is important in terms of decreasing transmission losses. The use of circularly polarized antennas presents an attractive solution to achieve this polarization match which allows for more flexibility in the angle between transmitting and receiving antennas. It reduces the effect of multipath reflections, enhances weather penetration and allows for any orientation to the communication system.

The objective of this paper is to design a single fed circularly polarized microstrip patch antenna that operates at 2.4 GHz. The main objectives are the comparative study and realization of circularly polarized microstrip patch antenna using symmetric slit. Compact symmetric slit square microstrip patch antennas are proposed for circularly polarized (CP) radiation. A symmetric slit on a patch radiator can be used for circularly polarized radiation with a compact size. Two slit shapes embedded along the four diagonal directions on the patch radiators are realized for compact circularly polarized.

Keywords: Wireless, microstrip antenna, circular polarization, slit.

I. INTRODUCTION

Highlight There is drastic change in communication technology and instruments in day to day life. So we require more sophisticated wireless communication equipment. The range and the scalability of systems are much dependent on the radio frequency which the system utilizes [1, 2]. Various Symmetric shaped slotted microstrip patch antenna with slits will be proposed for circularly polarized radiation and radio frequency identification applications [3]. In modern communication systems, like cellular phones, personal computer cards for wireless local area networks (WLAN) microstrip antenna are more preferred than any other radiator. The reason for application of these antennas is their low cost, light weight, low profile and easy integration with circuit components of portable personal equipment's.

A symmetric slit on a patch radiator can be used for circularly polarized radiation with a compact size[1, 4-7]. Finally many applications require compact circularly polarized microstrip antennas (CPMAs) where the overall antenna size is a major consideration like radio-frequency identification (RFID) handheld readers, cellular networks, portable wireless devices, wireless LANs and receiver antennas for medical implants are examples[8-10].Conventional microstrip antennas in

general have a conducting patch printed on a grounded microwave substrate, and have the attractive features of low profile, light weight, easy fabrication, and conformability to mounting hosts.

The major advantage of single feed CPMAs is their simple structure and compactness, which does not require an external polarizer, by using less board space than dual-feed CPMAs. Many designs of single-feed, CPMAs with square or circular patches are known earlier; various CP designs with a compact patch size at a fixed operating frequency had been reported. In these designs, the compact CP techniques used include embedding a cross slot of unequal arm lengths, embedding a Y-shaped slot of unequal arm lengths, inserting slits or spur lines at the patch boundary, truncating patch corners or tips. For feeding these compact CP designs, a probe feed or an edge-fed microstrip line feed can be used. Several possible designs for solving this problem have been reported, and details of the designs applied to a corner-truncated square microstrip antenna are presented. For the case of a pair of slits, CP radiation of microstrip antenna operated at the TM₁₁ mode has been achieved [11, 16].

II. STRUCTURE AND DESIGN

2.1 Design Specification

For designing Square microstrip patch antenna following procedure is required

$$W = \frac{1}{2f_r \sqrt{\mu_0 \epsilon_0}} \sqrt{\frac{2}{\epsilon_r + 1}} = \frac{v_0}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

$$\epsilon_{r_{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-0.5} \quad (2)$$

Where, v_0 is the free-space velocity of light. Determine the effective dielectric constant of the microstrip antenna using (2), Once W is found, determine the extension of the length ΔL using

$$\Delta L = h \left[\frac{(\epsilon_{\text{reff}} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{\text{reff}} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \right] \quad (3)$$

$$L = \frac{1}{2f_r \sqrt{\mu_0 \epsilon_0} \sqrt{\epsilon_{\text{reff}}}} - 2\Delta L \quad (4)$$

2.2 Design Parameter

This paper achieves circular polarization by introducing a perturbation in the form of truncating two opposite edges of a basic square patch antenna. Truncated edges have been used to achieve circular polarization in square, elliptical and circular patch. Finally we obtain the design structure for circular polarization with truncated corners.

TABLE 1: Design Parameter for square patch antenna

Patch Shape	Square
Patch Length	29.44
Substrate Length	39.04
Height of substrate	1.6 mm
Frequency	2.4 GHz
Dielectric constant of substrate FR4	4.4
Feeding method	Coaxial Probe Feed
Probe Feed Position	7.6mm in Y direction

We have constructed square microstrip patch antenna as per the design calculation or parameter. So we obtain following design parameter using the design procedure to construct the proposed antenna on Ansoft HFSS software for the antenna design. The good results are obtained by optimizing the truncated corner with one diagonal.

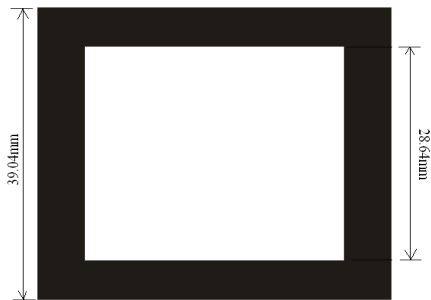


Fig.1: Microstrip square Patch Radiator

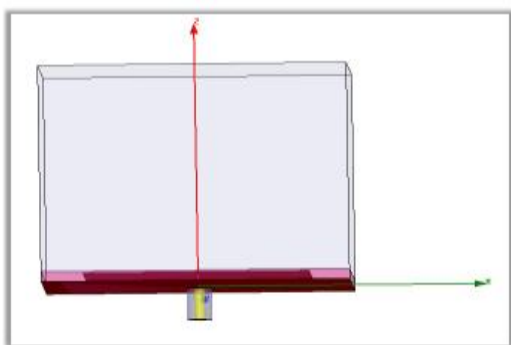


Fig.2: Cross Sectional View

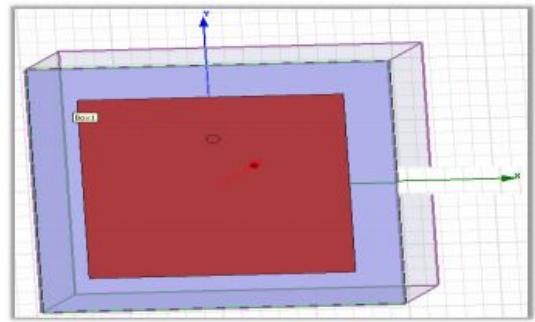


Fig.3: Microstrip square Patch Radiator

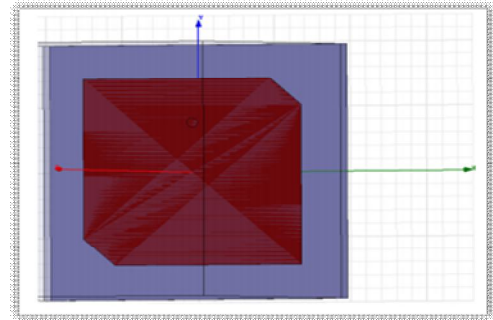


Fig.4: Truncated Corner on HFSS

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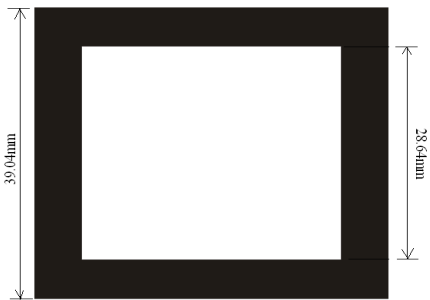


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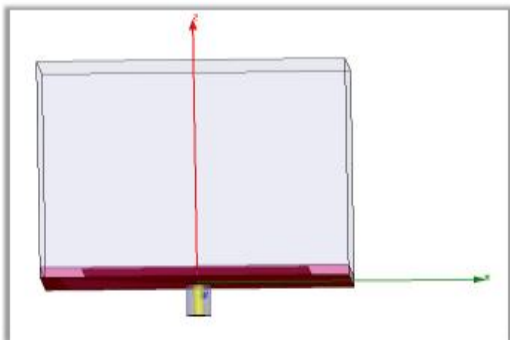


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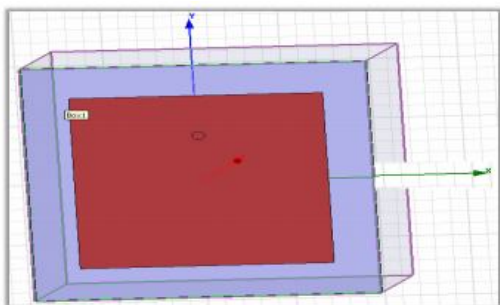


Fig.3: Microstrip square Patch Radiator

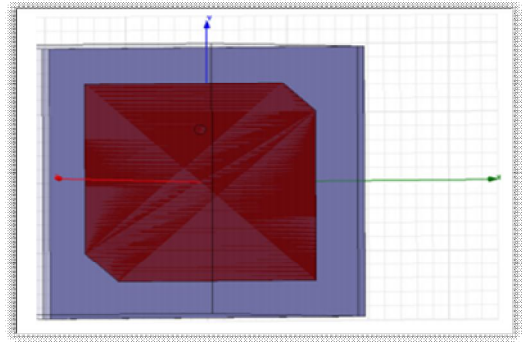


Fig.4: Truncated Corner on HFSS

III. DESIGN METHODOLOGY

1. With the help of simulation software Ansoft HFSS following design variation were followed:
 - By varying the slit circumference along one of the diagonal axes with respect to the other diagonal axis on a patch radiator, circularly polarized radiation can be achieved with compact size.
 - The performance of the antennas is compared, based on fixed overall antenna size and patch radiator size. Circularly polarized microstrip antennas based on larger-perimeter types of slits are more compact.
 - Following are Different slit shapes embedded in microstrip square patch radiators:
 - i) Truncated corners
 - ii) Truncated corners and slits
 - iii) V-shaped slits
 - iv) Rectangular slits
 - v) V-shaped slits and square slits
 - vi) Combined V-shaped and circular slits
 - Slits along the diagonal directions of the patch can excite two resonant modes with equal magnitudes, and orthogonal to each other. By slightly changing the circumference of the slits in the diagonal directions, the resonance frequencies of the two orthogonal resonant modes can be slightly changed for the circularly polarized radiation requirements.
2. Using HFSS simulation we can observe following parameters: Return Loss, Gain, Bandwidth, VSWR, Directivity, and Radiation Pattern.
3. Fabrication of circularly polarized microstrip patch antenna using symmetric slit on FR4 substrate and verify all above mention parameters.
4. Compare simulation results and hardware implementation results.

IV. SIMULATION AND RESULTS

The proposed circularly polarized symmetric-slit microstrip antenna is optimized at around 2.4 GHz for the above mentioned dimensions. The simulated results of return loss, VSWR, axial ratio, radiation pattern is as plotted below:
 Return Loss: Figure 5: (a) shows simulated (a) and measured (b) results of a return loss of the main square microstrip patch antenna at resonant frequency of 2.4 GHz.

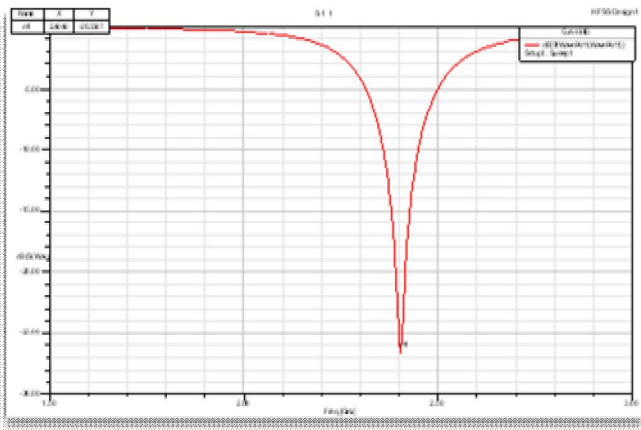


Fig.5: (a) Simulated Return Loss

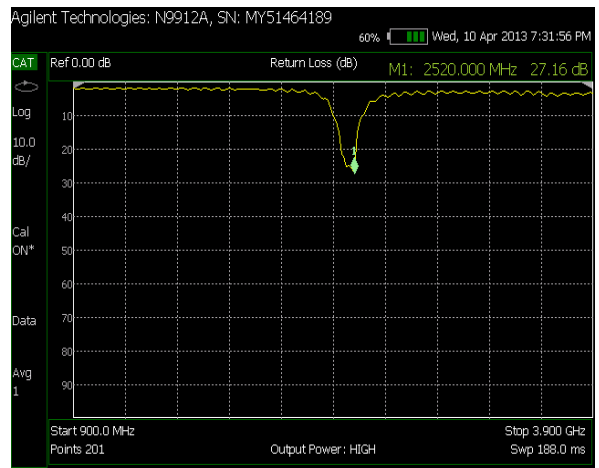


Fig.6: (b) Measured Return Loss

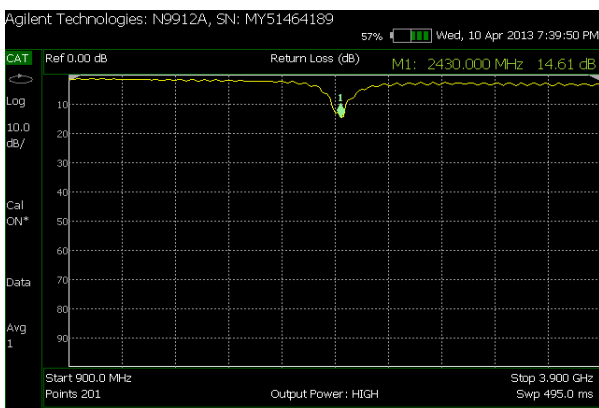


Fig.5: (b) Measured Return Loss

VSWR: Figure 7:(a)shows simulated and Figure 7:(b)shows measured results of VSWR less than 2 for the main square microstrip patch antenna at 2.4 GHz.

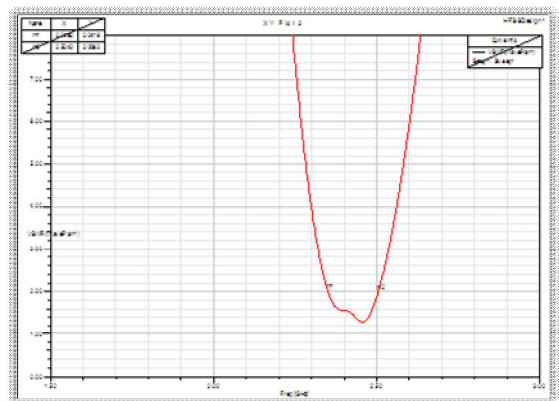


Fig.7: (a) Simulated VSWR

Figure 6: (a)shows simulated (a) and measured (b) results of a return loss of the proposed circularly polarized microstrip antenna at resonant frequency of 2.4 GHz and bandwidth is 150MHz (2.35-2.50GHz). This bandwidth gives a good agreement for the various wireless applications.

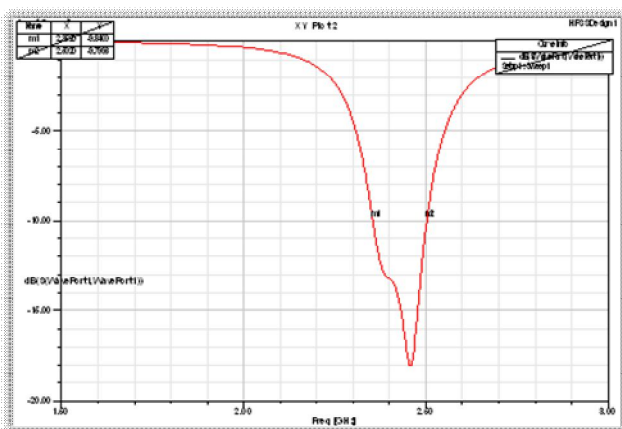


Fig.6: (a) Simulated Return Loss

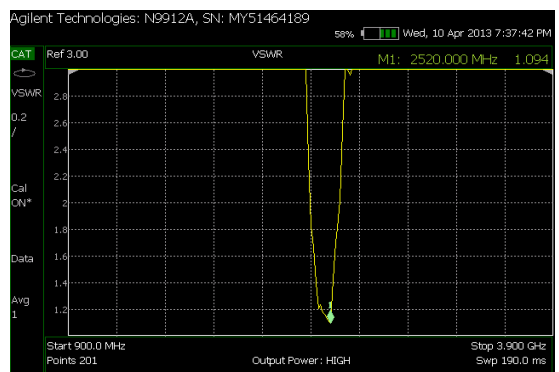


Fig.7: (b) Measured VSWR

VSWR: Figure 8:(a)shows simulated and Figure 8:(b)shows measured results of VSWR less than 2 for the truncated corner antenna at 2.4 GHz

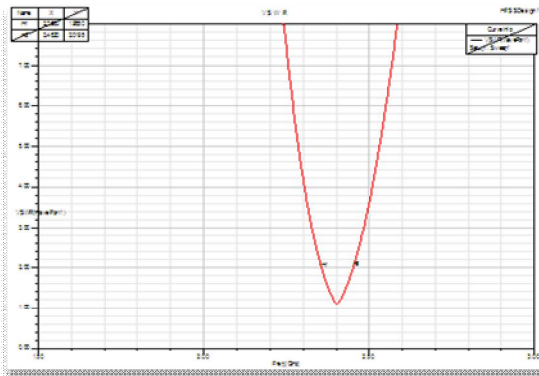


Fig.8: (a) Simulated VSWR

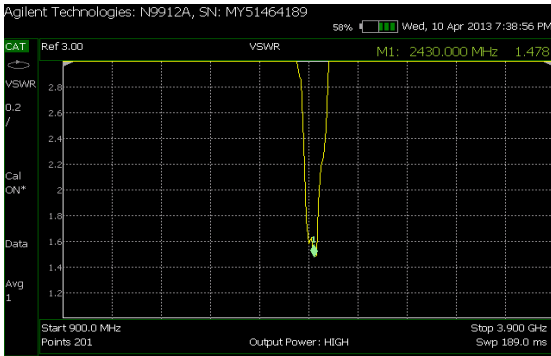


Fig.8: (b) Measured VSWR

Axial Ratio Value: Figure 9 shows an axial ratio of the proposed antenna resonating at frequency of 2.4 GHz is (2.5 dB) below 3dB. The axial ratio is the ratio of orthogonal components of an E-field.

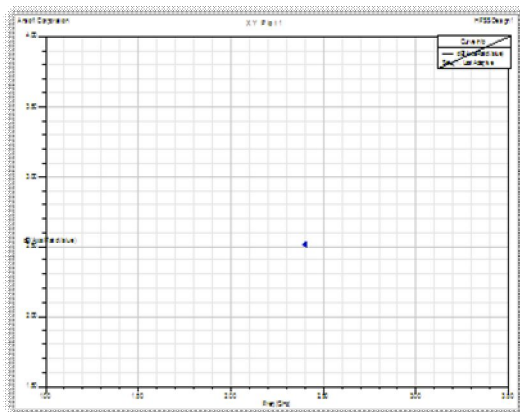


Fig.9: A. R. value of Truncated Corner

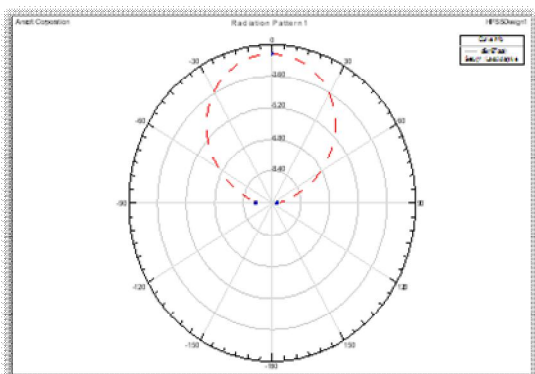


Fig.10: Radiation pattern of Truncated

Radiation Pattern: Radiation pattern is shown in Figure 10 for frequency 2.45 GHz. The radiation pattern is copolarized in H Plane.

TABLE 2: Comparison for various antenna parameters

Type	Frequency	S ₁₁	VSWR	Bandwidth
Main Square Patch simulated	2.4 GHz	-26.35 dB	1.0986	90MHz
Main Square Patch measured	2.4 GHz	-14.95 dB	1.6521	85.71 MHz
Truncated Corner simulated	2.4 GHz	-13.22 dB	1.5581	150 MHz
Truncated Corner measured	2.4 GHz	-14.78 dB	1.7200	139.28 MHz

TABLE 3: Comparison for various antenna parameters

Variables	Truncated Corner	Main Square Patch	% Improvement In Performance
Radiation Intensity	753.44 μW/sr	653.22 μW/sr	15.34
Directivity	1.4247	1.22791	15.96
Gain	0.92431	0.81561	13.32
Radiated Power	6.6456 mW	6.4177 mW	3.55
Accepted Power	10.244 mW	10.065 mW	1.77
Incident Power	10.0794 mW	10.066 mW	0.133
Radiation Efficiency	67.87	63.76	6.44
Bandwidth	156 MHz	98 MHz	59.18

V. CONCLUSIONS

The proposed method of using symmetric slits with a microstrip patch gives circular polarization. It has also provided an improved performance with respect to Return Loss, Bandwidth, VSWR, Gain, Directivity, and Radiation Pattern. Hence a detailed study about the various slit structure may provide better results and improved compact structure.

This technology can provide a range of benefits including the realization of a future proof architecture with the ability to support wireless devices and standards. It provides a flexible, reliable and cost effective approach for

developing circularly polarized antenna using symmetric slit.

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