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Design of a Circularly Polarized T – Stub Coupled Microstrip Patch Antenna for WLAN

Milind Thomas Themalil[1], Jibendu Sekhar Roy[2], Bhaskar Gupta[3]

[1]Department of Electronics and Communication Engineering
Believers' Church Caarmel Engineering College, Kerala – 689711, India
[1]milindthomas@gmail.com

[2]School of Electronics Engineering, KIIT University,
Bhubaneshwar – 751024, India
[2]drjsroy@rediffmail.com

[3]Department of Electronics and Telecommunication Engineering, Jadavpur University,
Kolkata – 700032, India
gupta_bh@yahoo.com

ABSTRACT – In this paper a new way of feeding single layer microstrip patch antenna to generate circular polarization using electromagnetically coupled microstrip T junction is proposed. The proposed antenna eliminates the need for capacitors in the RF path for active antenna applications in wireless local area network (WLAN). The simulated results using IE3D software were verified by measurement using the vector network analyzer.

Keywords – Active antenna, T – coupled junction, DC Isolation, circular polarization, axial ratio

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1. INTRODUCTION

Modern wireless communication systems require antennas for different systems and standards with characteristics like compactness, broadband operation, and multiple resonant frequencies with moderate gain. Because of many attractive features, microstrip patch antennas have received considerable attention for wireless communication applications [1-6]. Active integrated antennas, combining the circuit and radiation properties into a single microwave integrated circuit or MMIC for WLAN applications has been a significant research area in the last decade [1]. The need for wireless broadband communications has increased rapidly in recent years demanding quality of service, security, handover, and increased throughput for the wireless local area networks (WLAN). The main aim of next generation wireless communication is high speed networking service for multimedia communication. One of the most important high data rate wireless broadband communication standard is ETSI high Performance local area network type (HIPERLAN) which uses the frequency band 5.15 - 5.725 GHz with omni-directional antenna. Dual or circularly polarized antennas, as far as active integrated antennas are concerned, are those which are compact and single layered, although many different antenna configurations have been studied [7-10].

A drawback of single layered patch antennas with probe feed and microstrip line feed for active antennas with dual polarization is their DC contact between ports through the patch. Applications such as active antennas require DC isolation between the ports. A solution is to use extra capacitors in the RF path or multilayer structures such as aperture coupled patches [11]. High quality lumped RF capacitors are expensive and difficult to model in the design process of active antennas. There can also be an increase in the physical size and cross polarization levels. Circular polarization provides greater flexibility in orientation angle between transmitter and receiver, better mobility and weather penetration and reduction in multipath reflections and other kinds of interferences. So, circularly polarized antennas are widely used in various wireless systems. However, inherent limitations include the achievable impedance and axial-ratio bandwidths.

Researchers have made plenty of investigations on this subject [13-22]. These investigations include design of circularly polarized microstrip antennas with single feed (narrow axial ratio bandwidth) and also with double feed (relatively wide axial ratio bandwidth). The proposed structure, presented in this paper, is capable of providing DC as well as RF isolation, direct 50Ω matching and increased bandwidth compared to other single layer feeding methods. The antenna is circularly polarized in broadside direction which is an attractive feature for WLAN applications. Good gain and axial ratio bandwidth are obtained.

2. DESIGN OF THE PROPOSED ANTENNA STRUCTURE

The proposed antenna consists of two electromagnetically coupled microstrip T junctions on the adjacent sides of a square microstrip patch as shown in figure 1. The microstrip T junctions act as an impedance transformer, transforming the high radiation resistance of the patch to the desired low impedance. Since the microstrip Ts have DC isolation between them, capacitors in the RF path can be avoided for dual polarized active antenna applications. The small width of the microstrip T causes the directions of currents in the two arms of the microstrip T close to the patch to be in opposite directions and opposite to the excited TM_{10} or TM_{01} mode. Therefore the normal patch radiation pattern is not affected significantly by the microstrip T. By adjusting the length of the microstrip T arm and the gap between the patch and the T arm we can achieve 50Ω impedance match at the port. Size of patch is 16.8 mm X 16.8 mm. The T – Coupling is provided on both radiating and non-radiating edge and is fed by a single co-axial probe. Two rectangular slots cut out on the patch on opposite sides provides circular polarization (figure 1). The cutting out of slots on opposite edges significantly improves bandwidth besides providing circular polarization. The co-axial probe feed point is -10mm to the left of centre and -3mm below the centre of the patch. In this simulation a 6dBi Gain Bandwidth of 350 MHz is obtained.

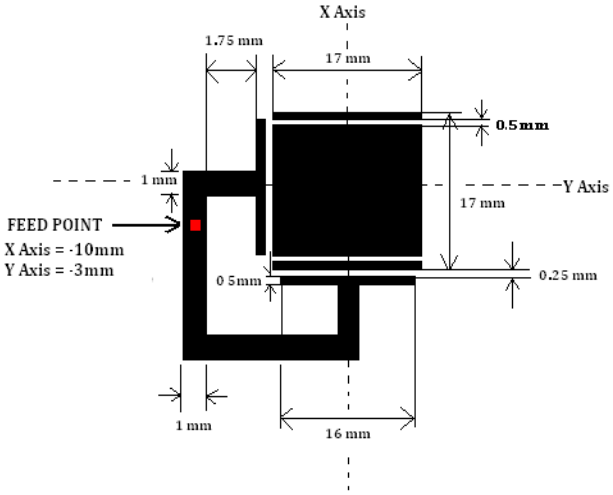


Figure 1: Top View of the Microstrip T-Stub Coupled Patch Antenna

The antenna was fabricated on a 1.6 mm thick PTFE Substrate with dielectric constant ε_r=2.32 and loss tangent tanδ= 0.001. The fabricated antenna prototype is shown in figure 2.

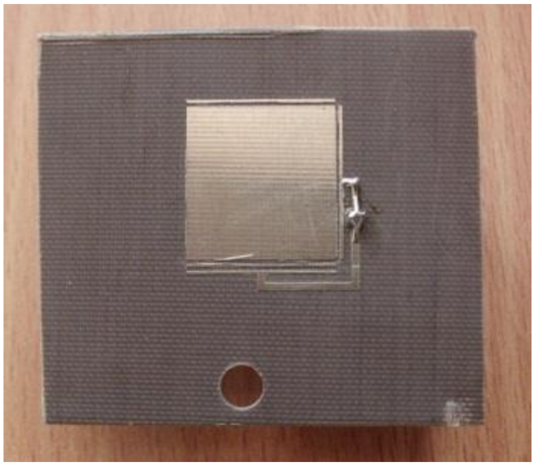


Figure 2: Photograph of Fabricated Microstrip T-Stub Coupled Patch Antenna

3. SIMULATED AND MEASURED RESULTS

The simulated and measured resonance frequencies are 5.22 GHz (figure 3) and 5.205 GHz (figure 4) respectively. The simulated and measured return losses are -27 dB (figure 3) and -25 dB (figure 4). Simulated axial ratio is shown in figure 5. Minimum axial ratio is 0.2 dB. The simulated and measured -10 dB impedance bandwidth are 380 MHz (figure 6) and 350 MHz (figure 4) respectively.

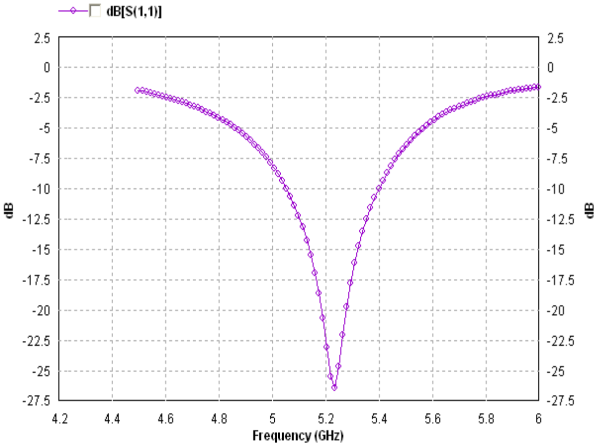


Figure 3: Simulated Return Loss

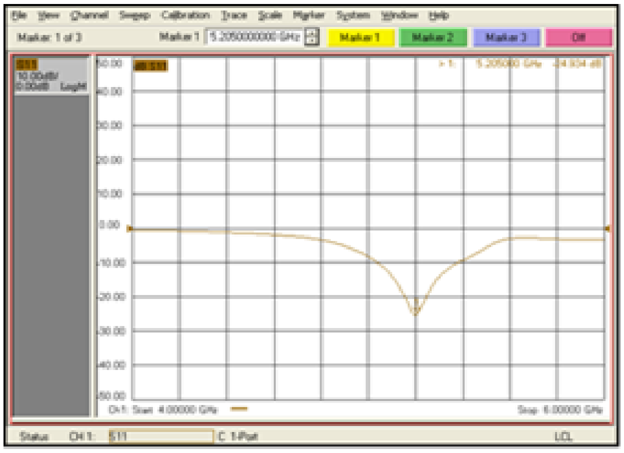
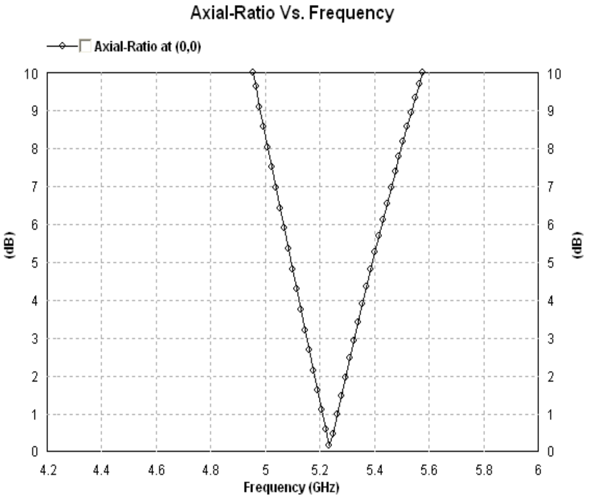


Figure 4: Measured Return Loss



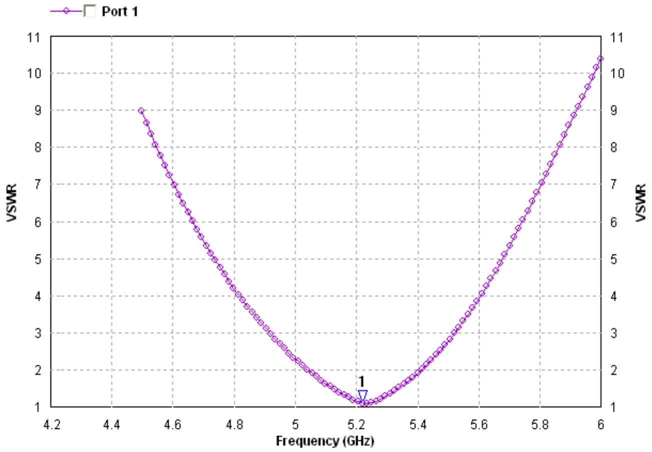


Figure 5: Simulated Axial Ratio

Figure 6: Simulated VSWR

The radiation pattern and plot for antenna gain are presented in figure 7 and figure 8 respectively. The antenna radiates in the broadside direction (figure 7) and the highest gain obtained is 6.5 dBi (figure 8). The 6 dBi gain-bandwidth product is 350 MHz which is well within the range of the proposed WLAN application in the 5.2 GHz band. So a good gain is obtained throughout the entire range of application and the antenna has 77% antenna efficiency (figure 9).

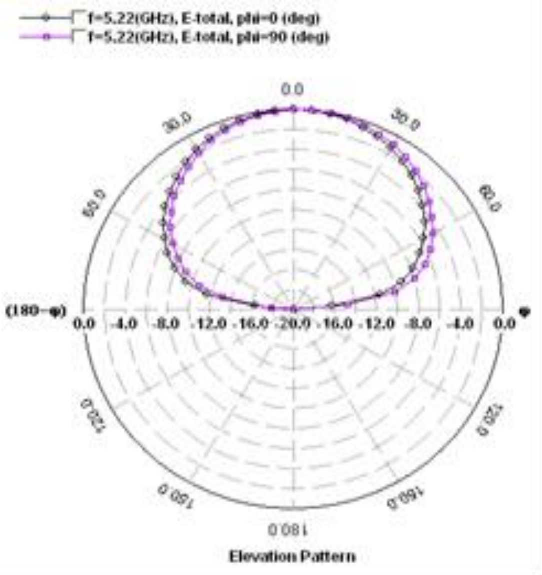


Figure 7: Simulated Radiation Pattern

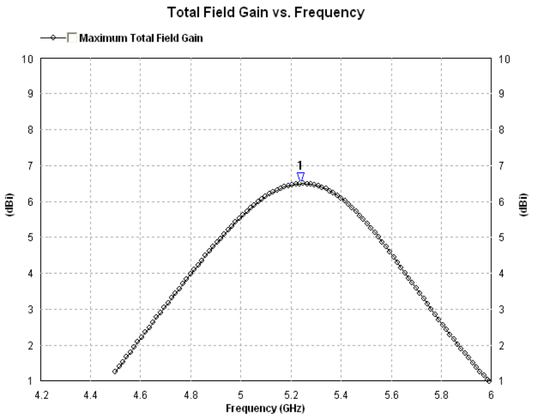


Figure 8: Simulated Gain

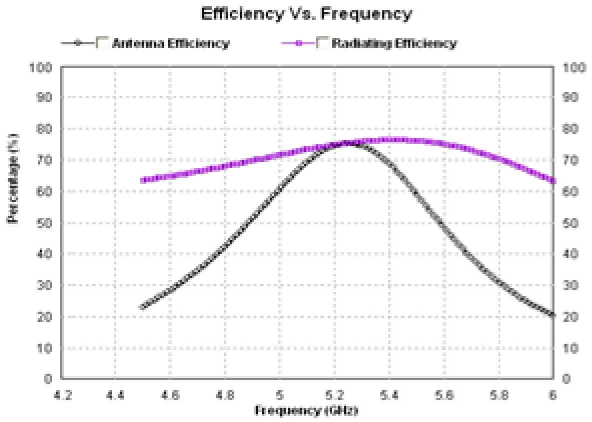


Figure 9: Simulated Efficiency

Table 1 and Table 2 show the simulated and measured results.

Table 1: Simulated Results

Res. Freq.	Return Loss S_{11}	10 dB Bandwidth MHz	Maximum Gain	6 dBi Gain Bandwidth	Minimum Axial Ratio	3dB Axial Ratio Bandwidth	Efficiency
5.22 GHz	-27 dB	380 MHz	6.5 dBi	350 MHz	0.2 dB	180 MHz	77 %

Table 2: Measured Results

Resonance Frequency	Return Loss S_{11}	10 dB Return Loss Bandwidth
5.205 GHz	-25 dB	350 MHz

4. CONCLUSION

A compact broadband circularly polarized microstrip patch antenna based on microstrip T-coupled ports was simulated using IE3D software. The antenna may be used for WLAN application. The simulated results are verified by measurement using the vector network analyser. For active antenna applications, the proposed structure does not need any capacitor in the RF path of the circuit.

5. ACKNOWLEDGMENT

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