Chapter 4

# Circularly Polarized T-Stub Coupled Microstrip Antenna Structure for WLAN

Milind Thomas Themalil

Additional information is available at the end of the chapter

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**Abstract**

In this chapter, a novel feeding mechanism for single layer microstrip patch antenna to generate circular polarization using electromagnetically coupled microstrip T junction is presented. The antenna structure eliminates the need for capacitors in the RF path for active antenna applications in wireless local area network (WLAN). The simulated results were verified by measurement using the vector network analyzer.

**Keywords:** active antenna, DC isolation, T-stub coupled, circularly polarized

## 1. Introduction

Wireless local area networks (WLAN) use antennas with different standards having characteristics such as miniaturization, conformability, wideband operation, multiple resonances and good gain. New microstrip antenna designs hence provide an ideal solution due to these features [1, 2]. Active antennas integrate the circuit with radiation properties into a monolithic microwave integrated circuit; a significant research area in recent years. Broadband wireless communications have increased rapidly in recent years demanding quality of service, security, handover and increased throughput for the wireless local area networks. The aim of next generation wireless communication is high-speed networking service enabling multimedia communication. An important high data rate wireless broadband communication standard is ETSI high performance local area network type 2 (HIPERLAN 2) which uses 5.15–5.725 GHz band with omni-directionality. Dual circularly polarized antennas, as far as active integrated antennas are concerned, are compact and single layered.

A drawback of single layered patch antenna structures, whether probe fed or microstrip line fed, for active antennas with dual polarization, is their DC contact between ports via the patch.

Active antennas require DC isolated ports. A solution is to embed additional capacitors in the RF path or use multilayered structures like aperture coupling. High Q lumped RF capacitors are monetarily expensive and complicated to model in the design process of active antennas, with an increase in the physical size and cross polarization levels. Circular polarization provides flexibility in antenna orientation between transmitter and receiver, better mobility, weather penetration features and reduction in multipath fading effects. However, some inherent limitations include the attainable impedance and axial ratio bandwidths [3, 4]. Plenty of investigations have been carried out on this subject, which include design of circularly polarized microstrip antennas with single feed and narrow axial ratio bandwidth and also with double feed with relatively wide axial ratio bandwidth. The structure presented in this chapter is capable of providing DC as well as RF isolation, direct 50 Ω matching and increased bandwidth compared to other single layer feeding mechanisms. The antenna is circularly polarized in broadside direction which is an attractive feature for WLAN applications. Good gain and axial ratio bandwidth are attained.

## 2. Design of the antenna structure

The antenna structure presented in this chapter consists of two-coupled microstrip T junctions on adjacent sides of a square patch as shown in **Figure 1**. The T junctions transform the high radiation resistance of the patch to lower impedance [5]. The microstrip Ts have DC isolation between them; there is no need for capacitors in the RF path in dual polarized active antenna applications [6, 7]. The small width of the microstrip T causes the currents in the two

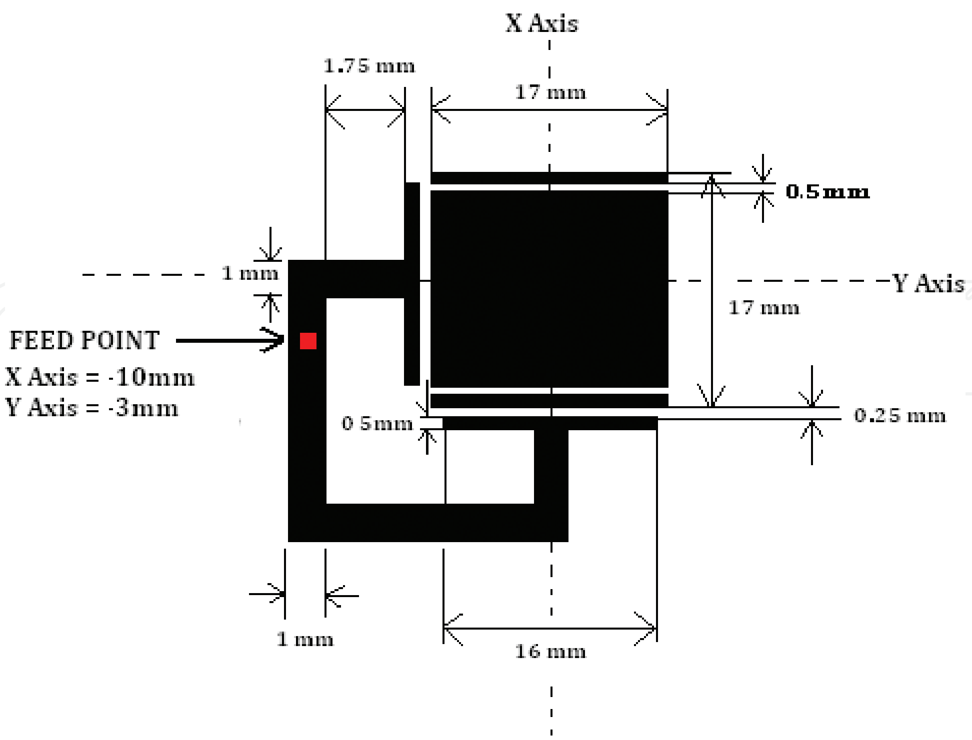


**Figure 1.** Top view of the microstrip T-stub coupled patch antenna.

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arms of the microstrip Ts to be in opposite directions to the excited TM modes. Therefore, the radiation pattern of the structure is not affected significantly by the microstrip T. By controlling the length of the T arm and the distance between the patch and the T arm, we can achieve 50 Ω impedance match. Dimension of the patch is 16.8 mm × 16.8 mm. The T-arms provided on both radiating and non-radiating edge are fed by a co-axial probe. Two rectangular slots loaded on the patch on opposite sides provide circular polarization as in **Figure 1**. Slot loading on opposite edges significantly improves bandwidth besides providing circular polarization [8]. The co-axial probe feed point is 10 mm to the left of centre and 3 mm below the centre of the patch. In this simulation, a 6 dBi gain bandwidth of 350 MHz is obtained.

The antenna was fabricated on a 1.6 mm thick PTFE substrate with dielectric constant $\varepsilon_r = 2.32$ and loss tangent tanδ = 0.001. The fabricated antenna prototype is shown in **Figure 2**.

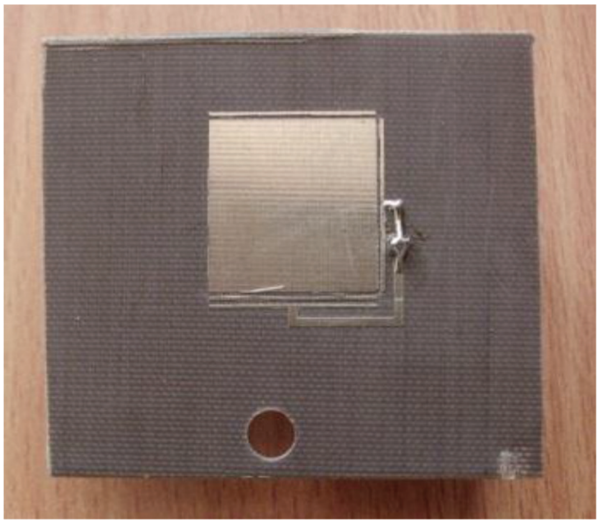

**Figure 2.** Photograph of fabricated microstrip T-stub coupled patch antenna.

## 3. Simulated and measured results for the structure

The simulated and measured resonance frequencies are 5.22 and 5.205 GHz as shown in **Figures 3** and **4**, respectively. The simulated and measured return losses are −27 and −25 dB as shown in **Figures 3** and **4**, respectively. Simulated axial ratio is shown in **Figure 5**. Minimum axial ratio is 0.2 dB. The simulated and measured −10 dB impedance bandwidths are 380 MHz as shown in **Figure 6** and 350 MHz as shown in **Figure 4**.

The simulated results of radiation pattern and gain of the structure are presented in **Figures 7** and **8**, respectively. Radiation is in the broadside direction and the highest gain obtained is 6.5 dBi. The 6 dBi gain bandwidth product is 350 MHz which is well within the range of the WLAN application in the 5.2 GHz band. A good gain is obtained throughout the entire range of application and the antenna has 77% antenna efficiency as shown in **Figure 9**.

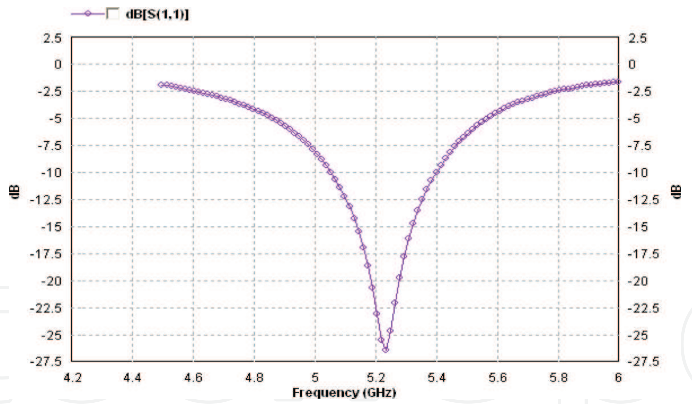


**Figure 3.** Simulated return loss.

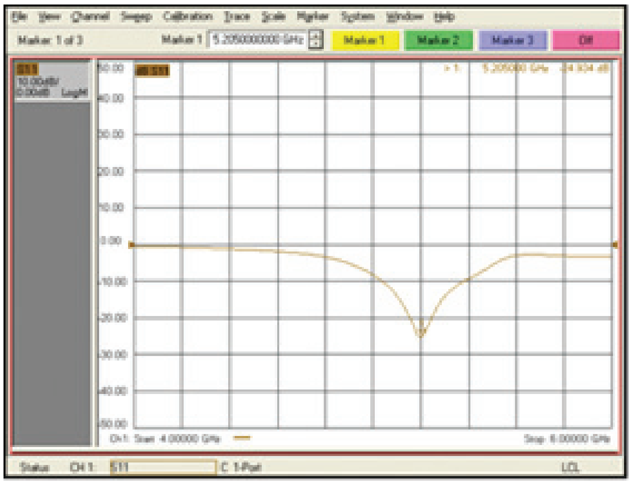


**Figure 4.** Measured return loss.

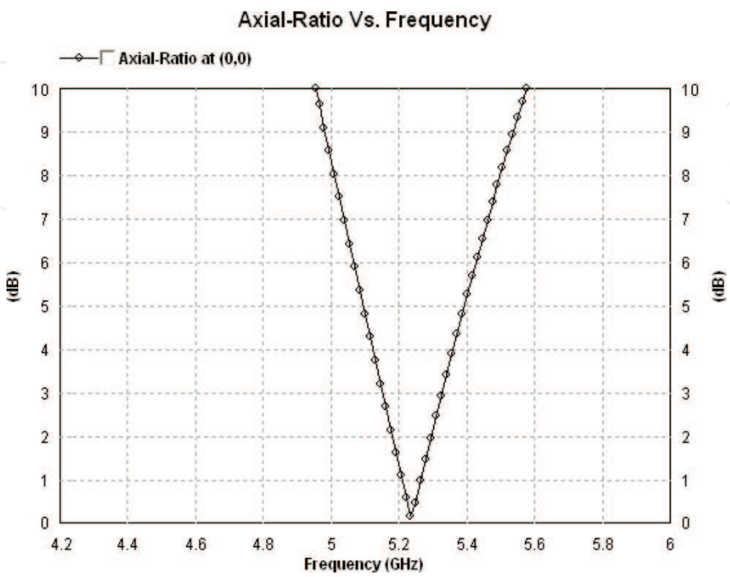


**Figure 5.** Simulated axial ratio.

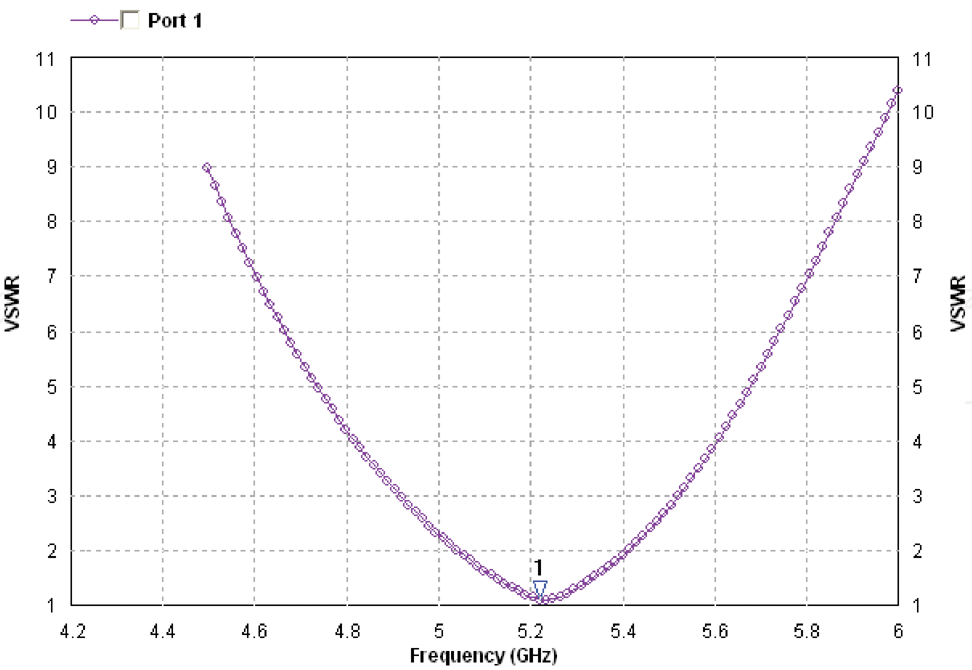


**Figure 6.** Simulated VSWR.

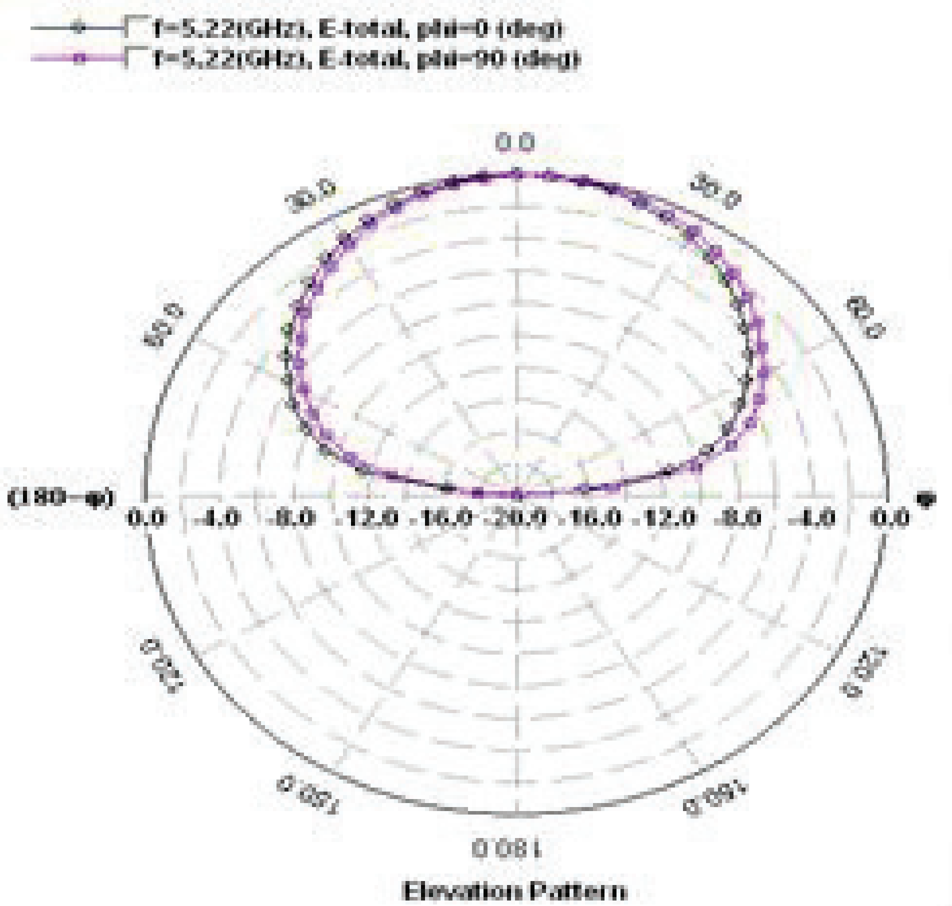


**Figure 7.** Simulated radiation pattern.

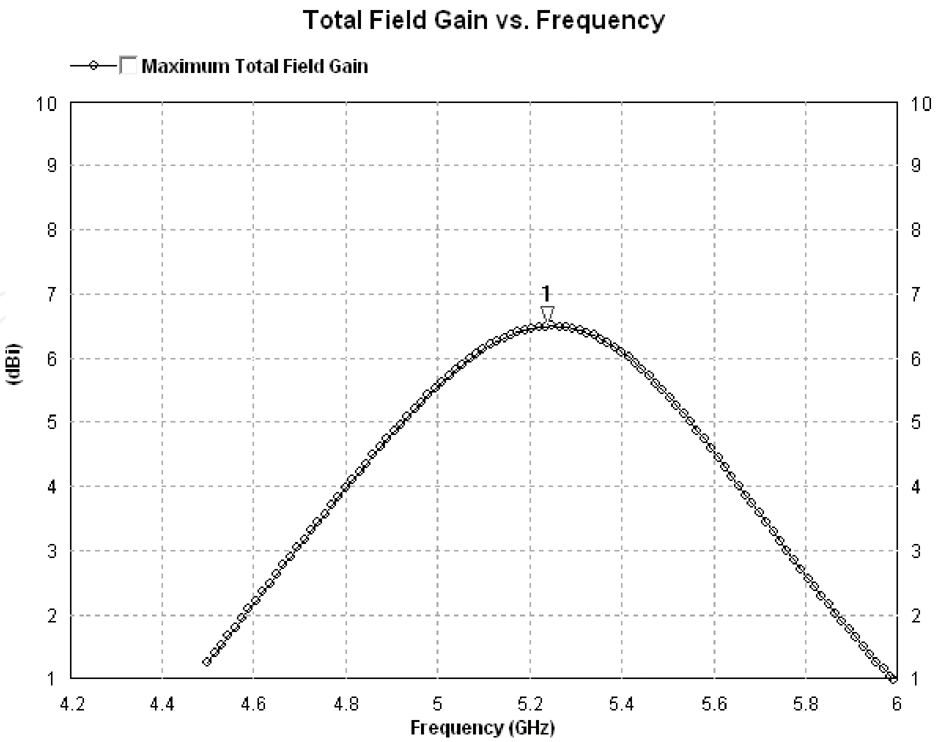


**Figure 8.** Simulated gain.

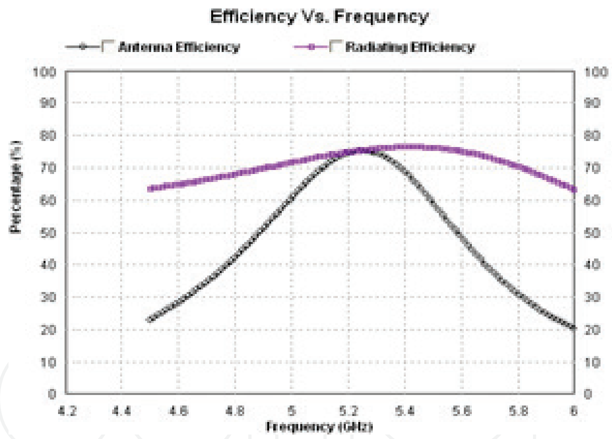


**Figure 9.** Simulated efficiency.

**Tables 1** and **2** show the simulated and measured results.

| Resonance frequency | Return loss $S_{11}$ | 10 dB Return loss bandwidth | Max. gain (dBi) | 6 dBi gain bandwidth | Min. axial ratio | 3 dB axial ratio bandwidth | Efficiency |
|---|---|---|---|---|---|---|---|
| 5.22 GHz | −27 dB | 380 MHz | 6.5 dBi | 350 MHz | 0.2 dB | 180 MHz | 77% |

**Table 1.** Simulated results.

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| Resonance frequency | Return loss $S_{11}$ | 10 dB return loss bandwidth |
|---|---|---|
| 5.205 GHz | −25 dB | 350 MHz |

**Table 2.** Measured results.

## 4. Conclusion

A compact and broadband circularly polarized microstrip patch antenna structure with T-shaped electromagnetically coupled ports was designed, simulated, fabricated and tested. The antenna structure is intended for active antenna WLAN applications. The simulated results are verified by the measurement using the vector network analyzer. For active antenna applications, the structure does not need any capacitor in the RF path of the circuit.

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## Author details

Milind Thomas Themalil

Address all correspondence to: milindthomas@gmail.com

Research & Development, Believers Church Caarmel Engineering College, Kerala, India

## References

[1] James JR, Hall PS. Handbook of Microstrip Antennas, London: Peter Peregrinus, 1989

[2] Pozar DM, Schaubert DH. Microstrip Antennas: Analysis and Design of Microstrip Antennas and Arrays, New York: IEEE Press, 1995

[3] Chung KL. A wideband circularly polarized H-shaped patch antenna, IEEE Transactions of Antennas and Propagation. 2010;**58**:3379-3383

[4] Chang FS, Wong KL, Chiou TW. Low-cost broadband circularly polarized patch antenna. IEEE Transactions of Antennas and Propagation. 2003;**51**:3006-3009

[5] Kurup DG, Rydberg A, Himdi M. Compact microstrip T – coupled patch antenna for dual polarization and active antenna applications. Electronics Letters. 2002;**38**(21):1240-1241

[6] Choi DH, Park SO. Active integrated antenna using a T shaped microstrip coupled patch antenna. Microwave & Optical Technology Letters. 2005;**44**(5):434-436

[7] Chang K, Hummer KA, Gopalakrishnan GK. Active radiating element using FET source integrated with microstrip patch antenna. Electronics Letters. 1988;**24**:1347-1348

[8] Roy JS, Thomas M. Design of a circularly polarized microstrip antenna for WLAN. Progress In Electromagnetic Research, PIER M. 2008;**3**:79-90