# Bandwidth Enhancement of E-Shaped Patch Antenna Using Parasitic Radiator


[#]Zeeshan Zahid,
EE Department, National University of Sciences and Technology
Islamabad, zeeshan_qau@hotmail.com



## Abstract

A simple technique of bandwidth enhancement of E shaped patch antenna using a coplanar parasitic radiator has been presented. The E shaped patch antenna is coaxial probe fed and parasitic radiator is a rectangular strip. Adding the strip to the patch introduces additional resonance, responsible for the enhancement of bandwidth. The length and width of the strip have been optimized to achieve the aim. Both simulation and experimental study is conducted. The maximum measured impedance bandwidth is 43.47% and maximum simulated gain is 9.91 dBi. Measured and simulated results of reflection coefficient are in good agreement. The design has been simulated in HFSS.



**Keywords :** E shaped Patch antenna, Impedance bandwidth, Gain


## 1. Introduction

With the increasing demands in wireless communication systems, patch antennas have attained much interest due to their light weight, low profile and ease of fabrication. However, patch antennas also suffer from drawbacks like narrow impedance bandwidth, low efficiency and low gain. Many designs have been proposed to overcome these drawbacks. It is known that the use of thick air substrates can improve the antenna performance [1]. By inserting a pair of wide slits on one of the radiating edges of rectangular patch antenna, impedance can be matched over wide bandwidth [2]. The E shaped patch antenna with air substrate was introduced by Fan Yang et al., [3] with the achieved bandwidth of 30.3%. Various techniques of bandwidth enhancement of the patch antenna have been proposed. These techniques vary in their design complexity and implementation cost. In [4], a modified E patch antenna is presented using a tuning stub. Using this technique, the reported bandwidth is 7.2%. In [5], a bandwidth enhancement of low profile E shaped antenna using distributed LC circuit on the back side of the patch is presented with achieved bandwidth of 9%. A broadband E-H shaped patch antenna [6] is presented with L-probe feed having 30% bandwidth and 9.37 dBi gain. Many efforts are made to make E patch a low profile antenna, maintaining wide bandwidth. In [7] a low profile, triple resonant E shaped antenna with L-probe is presented with bandwidth 19.8%. The techniques with L-probe and distributed LC network are difficult to match and fabricate whereas the others are not cost effective. Therefore a technique of bandwidth enhancement for E shaped patch antenna that is low cost, easy to match and fabricate while maintaining high gain is lacking in literature. In this paper, a conventional technique of bandwidth enhancement using parasitic radiator has been effectively employed on E shaped patch antenna. A passive rectangular radiator is placed in the plane of the patch causing the increase in impedance bandwidth. Initially the E shaped patch antenna with air substrate is designed for 3.3–4.65 GHz (bandwidth of 33.29%) with maximum gain of 10.14 dBi. Then the dimensions and location of coplanar rectangular strip are optimized to enhance the bandwidth up to 40.38% with maximum gain of 9.91 dBi. Simulated and measured results for both the designs are shown for comparison.

The paper is organized as follows. The section II describes the design geometry of the antenna. In section III, simulation and measured results are presented. Finally the concluding remarks are given in section IV.

## 2. Antenna Design

The geometry of proposed antenna is shown in figure 1. The design consists of E patch and a rectangular parasitic radiator. The structure is mounted on 8cm×8cm ground plane. Patch antenna, parasitic radiator and ground plane are made of 17µm thick copper sheet. The antenna is coaxial probe fed where the location of the probe on the E patch is shown by a small circle in figure [1]. The structure uses a relatively thick air substrate ($0.085\lambda_o$), where $\lambda_o$ is the free space wavelength at center frequency. The dimensions of the antenna are given in table 1.

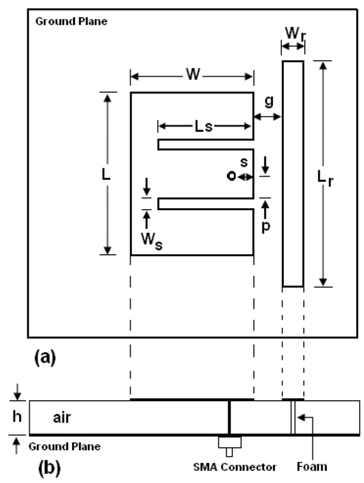



Figure 1. Geometry of E shaped patch antenna with parasitic radiator
(a) Top view (b) Side view

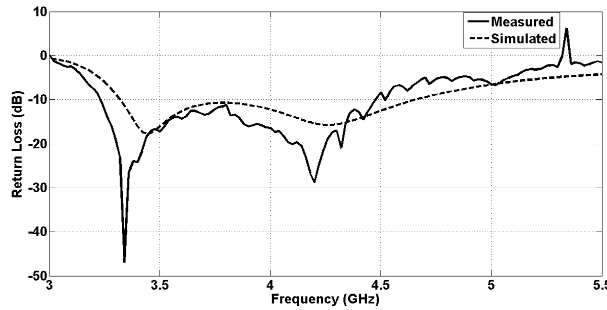
Table 1: Parameters of Proposed Antenna

| L | W | $L_s$ | $W_s$ | h | g | $L_r$ | $W_r$ | s | p |
|---|---|---|---|---|---|---|---|---|---|
| 39.7 | 30 | 23.5 | 2.3 | 6.5 | 7 | 50.5 | 0.5 | 5 | 6 |

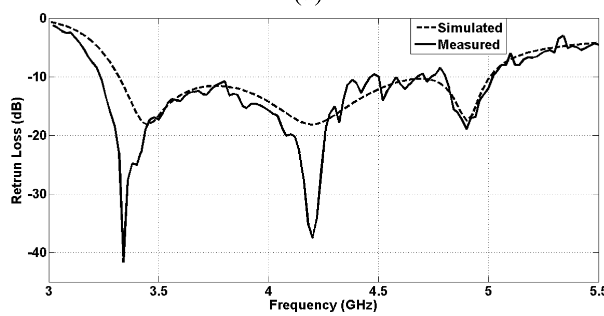
The center of the ground plane and that of E patch are the same. The inserted slots are of equal lengths ($L_s$), equal widths ($W_s$) and located at equal distances from the probe location. The coplanar parasitic radiator is placed in front of the edge of the patch where the slots are inserted. It is mounted on a support of foam so that it lies in the plane of the patch. Passive radiator has some degrees of freedom that control the additional resonance. They include length ($L_r$), width ($W_r$), height (h) and location near E patch. The EM simulator Ansoft HFSS 11 is used for optimization and simulation process. The software uses finite element method (FEM) for numerical calculation.

## 3. Results and Discussion

In this section simulated and measured results of E shaped antenna with and without parasitic radiator are presented. The E shaped antenna is a wideband antenna with two resonant frequencies [3]. The proposed design with parasitic radiator introduces third resonance. Firstly an E shaped antenna (without parasitic radiator) is designed for wideband operation. Figure 3 shows the simulated and measured results of the design. The impedance bandwidth has been measured using Agilent 8362B vector network analyzer. The achieved simulated bandwidth (return loss < -10dB) is 32.3% (3.3–4.65 GHz) with the first and second resonances occur at 3.45 GHz and 4.2 GHz respectively. The experimentally measured bandwidth is 33.29% (3.23–4.52 GHz). When the coplanar parasitic radiator is placed at the optimized location near the antenna, it introduces an additional resonance at 4.9 GHz that can be seen in figure 4. In this case the simulated bandwidth is

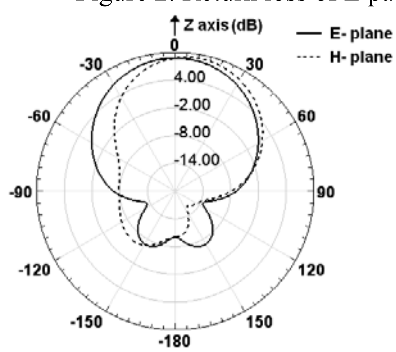



(a)

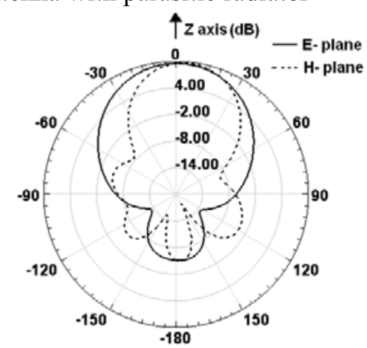



(b)

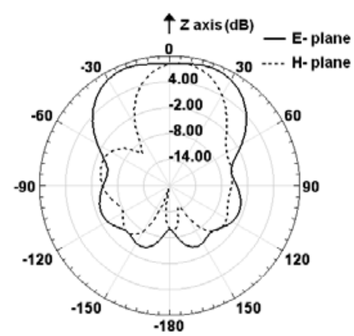
Figure 2. Return loss of E patch antenna with parasitic radiator




(a)




(b)




(c)

Figure 3. Simulated radiation pattern of E patch antenna with parasitic radiator at (a) 3.45 GHz (b) 4.2 GHz (c) 4.9 GHz

40.38% (3.32–5 GHz) whereas the measured bandwidth is 43.47% (3.24 GHz–5.03 GHz). The third resonance is due to the excitation of the coupling currents in the parasitic radiator near third resonance frequency. By this method, the improvement in impedance bandwidth is 10.18%. The difference in measured and simulated results is due to the tolerence of manufacturing process. Radiation patterns of the antenna with parasitic radiator at resonant frequencies are presented in figure 5. It can be noted that the E-plane patterns are symmetrical with respect to z axis. Figure 6

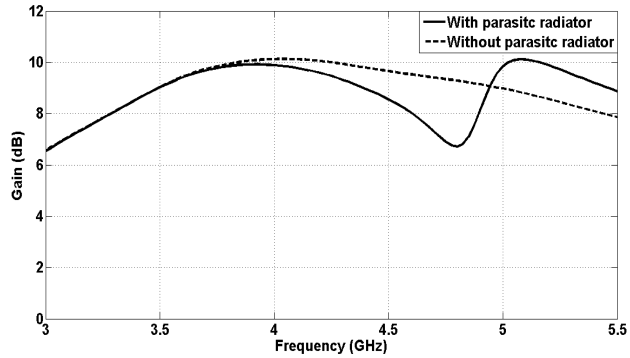



Figure 4. Simulated gain of E patch with and without parasitic radiator

shows the simulated gain of the antenna with respect to source frequency. The average gain of the designed E shaped antenna is 9.04 dBi with the peak value of 10.14 dB, whereas, with parasitic radiator the average gain is 8.85 dBi with the peak value of 9.91 dBi which is larger than the reported gain in [6]. The variation of current on E patch surface has been comprehensively studied in [3]. Here the current distribution on the proposed antenna at third resonance is discussed. At third resonant frequency the current in the upper half of the rectangular strip moves out of phase with the current in the lower half. The magnitude of current in the strip is very low near first resonance. As the frequency of source increases the magnitude of induced current also increases. As soon as it reaches its maximum value, third resonance occures responsible for enhancement of bandwidth.

## 4. Conclusion

A low cost and easy to fabricate solution of bandwidth enhancement of E shaped patch antenna is presented. Its bandwidth can be enhanced by using a coplanar parasitic radiator. The proposed design improves the bandwidth by 10.18%. The design method is also applicable to other patch antennas with slots. The proposed wideband antenna can be deployed in multistandard wireless communications.

## References


[1] Ayoub, "Analysis of rectangular microstrip antennas with air substrates," Journal of electromagnetic waves and applications, vol. 17, No. 12, pp. 1755-1766, 2003.

[2] Kin-Lu Wong, Wen-Hsiu Hsu, "A Broad-Band Rectangular Patch Antenna With a Pair of wide slits", IEEE transactions on antennas and propagation, vol. 49, no. 9, September 2001.

[3] Fan Yang, Xue-Xia Zhang, Xiaoning Ye, Yahya Rahmat-Samii, "Wide-Band E-Shaped Patch Antennas for Wireless communications," anisotropy," IEEE transactions on antennas and propagation, vol. 49, no. 7, July 2001.

[4] AngYu, XuexiaZhang, "A Method to Enhance the Bandwidth of Microstrip Antennas Using a Modified E shaped patch," Radio and Wireless Conference, pp. 261 – 264, August 2003.

[5] Yikai Chen, Shiwen Yang, and Zaiping Nie, "Bandwidth enhancement method for low profile e-shaped microstrip patch antennas," IEEE transactions on antennas and propagation, vol. 58, no. 7, July 2010.

[6] M. T. Islam, "Broadband E-H shaped microstrip patch antenna for wireless systems," Progress In Electromagnetics Research, PIER 98, 163,173, 2009.

[7] Jiang Xiong, Zhinong Ying, and Sailing He, "A Broadband Low Profile Patch Antenna of Compact Size with three resonances." IEEE transactions on antennas and propagation, vol. 57, no. 6, june 2009.