*Progress In Electromagnetics Research Letters, Vol. 50, 13–18, 2014*

# Desktop Shaped Broadband Microstrip Patch Antennas for Wireless Communications

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**Abstract**—This paper presents a comparative study of rectangular base desktop shaped broadband patch antenna (Antenna1) and triangular base desktop shaped broadband patch antenna (Antenna2). Apart from base dimensions all parameters of both antennas are constant. The broadband characteristics are achieved by introducing two parasitic ground planes and notches are etched on the radiating patch. Both antennas are simulated, fabricated and tested for obtaining the desired performance. The designed Antenna1 shows bandwidth of 39.97% (4.95 GHz to 7.42 GHz) whereas an improved bandwidth of 49.0% (4.53 GHz to 7.47 GHz) is achieved through Antenna2. Further, gain and radiation pattern of the two antennas are compared and discussed. The effect of inclination angle '$\alpha$' on Antenna2 characteristics in obtaining the improved bandwidth is also studied. The proposed antennas are simulated, and results are verified experimentally.

## 1. INTRODUCTION

Due to rapid development of modern wireless communication technologies, low cost, light weight and small size wideband antennas are of great demand. Microstrip patch antennas are developed in response to this need. Their planer profile configurations attract commercial, industrial and medical applications. However, the main limitation of the conventional microstrip patch antennas is narrow bandwidth that restricts its operation where wider bandwidth is required. To overcome their inherent limitation of narrow bandwidth, many techniques have been proposed and investigated such as by using lower value of dielectric substrate, increasing the thickness of substrate [1], utilizing an impedance matching networks and different types of feeding techniques [2–5], use of stacked and coplanar structures [6], loading of slot and notch [7, 8]. These techniques have some limitations except loading of slot and notch, because it enhances bandwidth without increasing the volume of the geometry. For these reasons, several structures have been reported by the research groups such as E-shaped antenna [9–12], E and H-shaped antennas [13], C-shaped antenna [14], notched semi-disk antenna [15], E-shaped ground penetrating patch antenna [16], $\psi$-shaped antenna [17], V-shaped and half V shaped antennas [18], W-shaped antenna, etc. [19] in which they achieved broad bandwidth. These antennas are fabricated on thin microwave substrates having two or more adjacent resonant frequencies which are excited near the fundamental frequencies. These closely excited resonating frequencies are combined to provide enhanced bandwidth. The concept of the proposed antenna structure has been extracted from the above discussed antenna shapes.

In this article, a novel design of desktop shaped rectangular base (Antenna1) and triangular base (Antenna2) microstrip patch antennas are presented. Antenna2 has better characteristics than Antenna1, which is proved by comparing the characteristics of both antennas in terms of bandwidth, gain and radiation pattern. The details of antenna geometry and characteristics are discussed in next sections.

*Received 29 September 2014, Accepted 31 October 2014, Scheduled 12 November 2014*
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## 2. ANTENNA GEOMETRY AND DIMENSIONS

Figure 1 shows the geometries of notch loaded rectangular patch antennas with finite size ground plane for broadband operation. The rectangular patch has a dimension of (29 mm × 30 mm) fabricated on a supporting substrate with 3.38 relative permittivity and 1.6 mm thickness. The proposed antenna is designed by etching rectangular notch on both radiating sides of the patch having dimensions (7 mm × 12.6 mm) as shown in Figure 1(a). After that, right angle triangle area 31.5 mm$^2$ on both sides of the rectangular notch are removed, and the desired antenna shape has been obtained as shown in Figure 1(b). The improvement in bandwidth has been achieved by separating a single ground plane of dimension (32 mm × 42 mm) into two parts (32 mm × 15 mm) and (32 mm × 22 mm) with 5 mm separation. The antenna is excited by a coaxial probe at position (0, 4) mm from the center. A prototype of the proposed patch antennas with geometrical parameters are fabricated as shown in Figure 2.

The current distributions of the proposed antennas at the center frequency are shown in Figure 3. From the figure, it is noticed that the current flows on the patch and in the ground plane are achieved

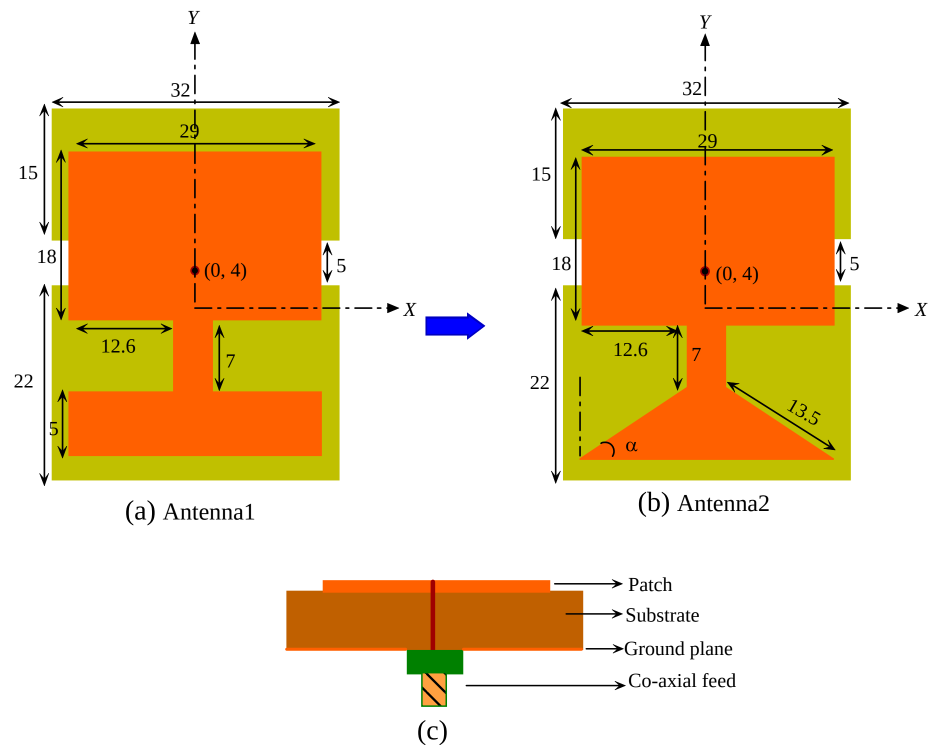


**Figure 1.** Geometrical configurations of the proposed antennas, (a), (b) top view and (c) side view (units are in mm).

**Figure 2.** Photograph of the fabricated antennas.

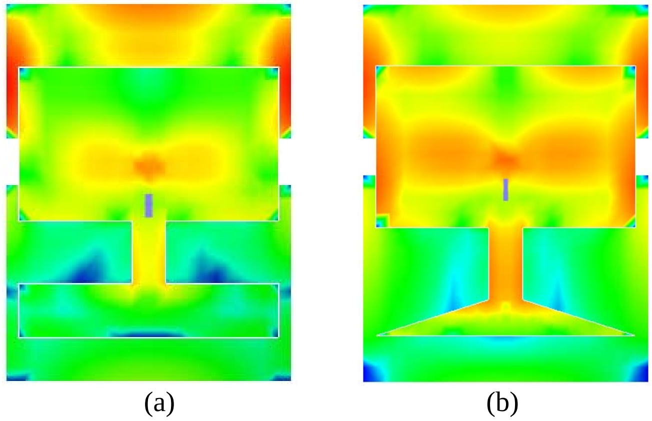


**Figure 3.** Current distribution of the proposed (a) Antenna1 at center frequency $f_r = 6.20\,\text{GHz}$ and (b) Antenna2 at center frequency $f_r = 6.0\,\text{GHz}$.

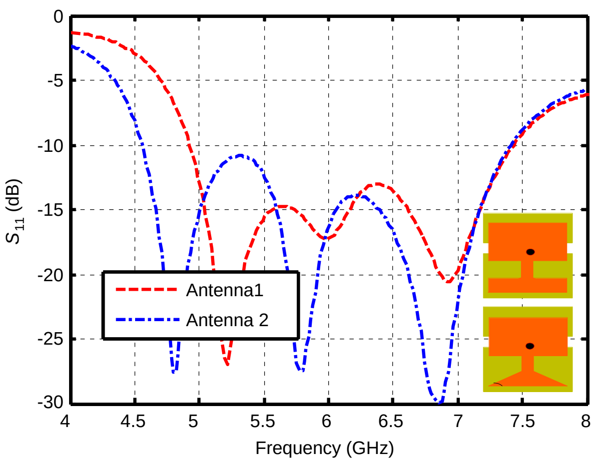


**Figure 4.** Comparative plot of reflection coefficient versus frequency for proposed Antenna1 and Antenna2.

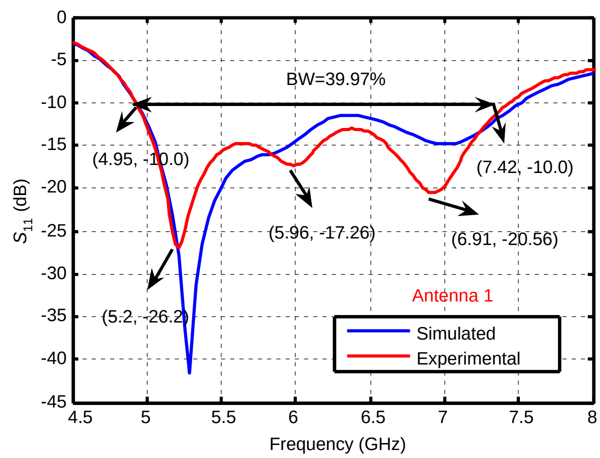


**Figure 5.** Plot of reflection coefficient versus frequency for proposed Antenna1.

by exciting the radiating patch. The fringing fields at the edges of the patch are responsible for the antenna radiation. When notches are introduced on the patch, they create new edges for fringing fields, which generate new resonating frequencies. These closely excited resonating frequencies are combined to give enhanced bandwidth.

## 3. RESULT AND DISCUSSION

The comparative plot for reflection coefficient versus frequency of the proposed Antenna1 and Antenna2 is given in Figure 4. From the figure, it is noticed that the bandwidth of Antenna1 is 39.97%, whereas Antenna2 improves bandwidth from 39.97% to 49.0%.

Simulated results are shown along with experimental ones for designed Antenna1 in Figure 5. From this figure, it is found that Antenna1 has three resonating frequencies, one at 5.2 GHz and the other two at 5.96 GHz and 6.91 GHz. These closely spaced resonating frequencies are combined to provide broader bandwidth. The frequency band of operation is obtained from 4.95 GHz to 7.42 GHz for reflection coefficient values less than $-10\,\text{dB}$. The antenna shows bandwidth of 39.97% (measured) and 40.96% (simulated). A small discrepancy occurs between simulated and measured results due to fabrication losses in experimental setup, and simulated results are taken in ideal conditions.

The frequency versus reflection coefficient plot for proposed Antenna2 is shown in Figure 6. The detailed information about designed Antenna2 characteristics are discussed in this section. From the result, it is clearly seen that the three close resonances are excited at frequencies 4.8 GHz, 5.78 GHz and 6.87 GHz, which combine to give broad bandwidth of 49.0% (measured) and 49.42% (simulated). The antenna bandwidth is determined from −10 dB reflection coefficient, and the center frequency is defined as $(f_L + f_H)/2$, where $f_L$ and $f_H$ are the lower and higher cutoff frequencies. The experimental results are obtained with the help of spectrum analyzer and the simulation performed by method of moment based simulator known as IE3D [20]. The experimental results are plotted with simulated results for proving the validation of the proposed antenna geometry.

The effects of tilt angle '$\alpha$' on the antenna characteristics are studied as shown in Figure 7. From the figure, it is found that when increasing the inclination angle from 21.30° to 32.41°, the corresponding bandwidth of the antenna decreases. Whereas when decreasing the inclination angle from 21.30° to 12.95°, it is found that the corresponding bandwidth again decreases. It means that the maximum bandwidth is obtained at an angle of 21.30°. It has been noticed that '$\alpha$' plays an important role on deciding the maximum bandwidth. The effect on bandwidth due to inclination angle '$\alpha$' is shown in Table 1.

The simulated and measured gains of the proposed antennas at various frequencies are shown in Figure 8. From the figure, it is clearly observed that the gain varies from 3.6 dBi to 3.0 dBi over an operating frequency range of 4.95 GHz to 7.42 GHz for Antenna1. Whereas, gain of Antenna2 varies from 4.1 dBi to 3.5 dBi over an operating frequency range of 4.53 GHz to 7.47 GHz.

The $E$-plane and $H$-plane radiation patterns of both antennas are shown in Figure 9. Comparing $E$-plane radiation patterns of Antenna1 and Antenna2, it is noted that $E$-plane radiations of the two geometries are nearly the same, in spite of difference in radiated power. Null in the radiation pattern represents the angles at which no power is transmitted. Similarly, results are analyzed for $H$-plane and found that beamwidth of Antenna1 is maximum in comparison to Antenna2. Both antennas give bidirectional radiation pattern due to effect of finite size ground plane.

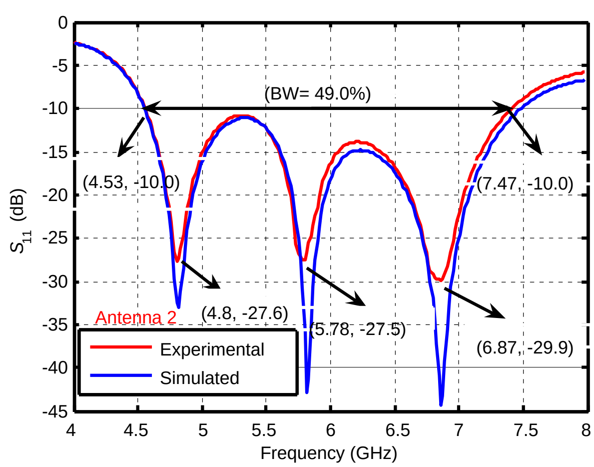


**Figure 6.** Plot of reflection coefficient versus frequency for proposed Antenna2.

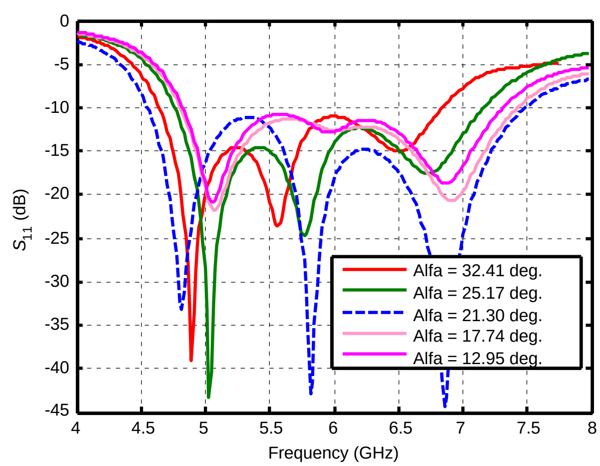


**Figure 7.** Variation of the reflection coefficient versus frequency at different inclination angles.

**Table 1.** The effect of inclination angle '$\alpha$' on the antenna characteristics.

| S. No | Inclination Angles (degree) | Lower Cut Off Freq. ($f_L$) | Upper Cut Off Freq ($f_H$) | Bandwidth (%) |
|---|---|---|---|---|
| 1. | 32.41° | 4.64 | 6.84 | 38.33 |
| 2. | 25.17° | 4.75 | 7.16 | 40.50 |
| 3. | 21.30° | 4.53 | 7.47 | 49.0 |
| 4. | 17.74° | 4.81 | 7.44 | 42.94 |
| 5. | 12.95° | 4.82 | 7.32 | 41.19 |

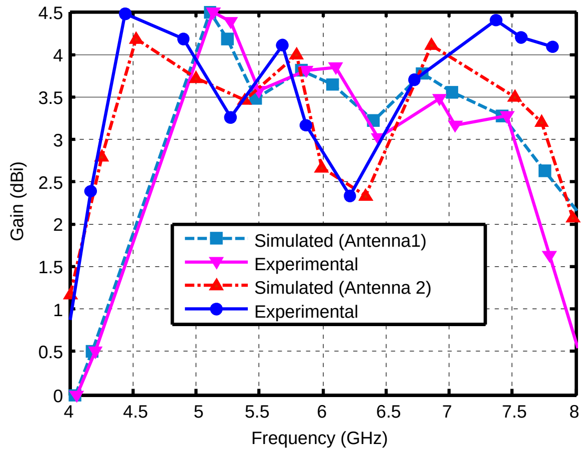


**Figure 8.** Gain versus frequency plot of proposed Antenna1 and Antenna2.

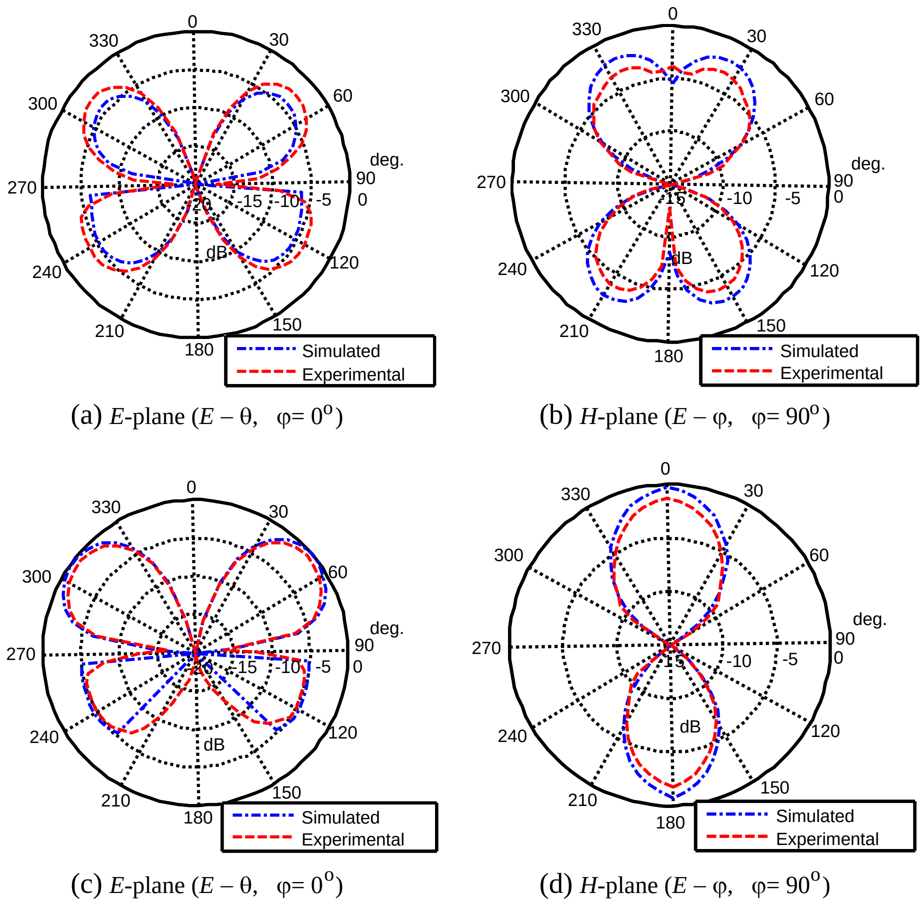


**Figure 9.** Radiation-field patterns of $E$ and $H$ plane for (a), (b) rectangular base desktop shaped patch antenna (Antenna1) at 6.20 GHz and (c), (d) triangular base desktop shaped patch antenna (Antenna2) at 6.0 GHz.

## 4. CONCLUSION

In this article, novel desktop shaped broadband microstrip patch antennas are successfully fabricated which are capable of supporting large frequency bandwidth of 39.97% and 49.0%. Simulated results of reflection coefficients, gain and radiation pattern are verified experimentally and observed in good agreements. Both antennas have sufficient bandwidth, and they can be utilized for modern wireless C band applications.

## REFERENCES


1. Schaubert, D. H., D. M. Pozar, and A. Adrian, "Effect of microstrip antenna substrate thickness and permittivity: Comparison of theories and experiments," *IEEE Transactions on Antennas and Propagation*, Vol. 37, 677–682, 1989.
2. Pues, H. F. and A. R. Van De Capelle, "An impedance technique for increasing the bandwidth of microstrip antennas," *IEEE Transactions on Antennas and Propagation*, Vol. 37, 1345–1354, 1989.
3. Sarin, V. P., M. S. Nishamol, D. Tony, C. K. Aanandan, P. Mohanan, and K. Vasudevan, "A broadband L-strip fed printed microstrip antenna," *IEEE Transactions on Antennas and Propagation*, Vol. 59, 281–284, 2011.
4. Guo, Y. X., K. M. Luk, and K. F. Lee, "L-probe proximity fed annular ring microstrip antennas," *IEEE Transactions on Antennas and Propagation*, Vol. 49, 19–21, 2001.
5. Mak, C. L., K. F. Lee, and K. M. Luk, "Broadband patch antenna with a T-shaped probe," *IEE Proceedings Microwaves, Antennas and Propagation*, Vol. 147, 73–76, 2000.
6. Danideh, A. and R. Sadeghi-Fakhr, "Wideband co-planar microstrip patch antenna," *Progress In Electromagnetics Research Letters*, Vol. 4, 81–89, 2008.
7. Rafi, G. H. and L. Safai, "Broadband microstrip patch antenna with V-slot," *IEE Proceeding Microwave Antenna Propagation*, Vol. 151, 435–440, 2004.
8. Mak, C. L., R. Chair, K. F. Lee, K. M. Luk, and A. A. Kishk, "Half U-slot patch antenna with shorting wall," *Electronics Letters*, Vol. 39, 1779–1780, 2003.
9. Ang, B. K. and B. K. Chung, "A wideband E-shaped microstrip patch antenna for 5–6 GHz wireless communications," *Progress In Electromagnetics Research*, Vol. 75, 397–407, 2007.
10. Chen, Y., S. Yang, and Z. Nie, "Bandwidth enhancement method for low profile E-shaped microstrip patch antennas," *IEEE Transactions on Antennas and Propagation*, Vol. 58, 2442–2447, 2010.
11. Chen, Y. and C.-F. Wang, "Characteristic-mode-based improvement of circularly polarized U-slot and E-shaped patch antennas," *IEEE Antennas and Wireless Propagation Letters*, Vol. 11, 1474–1477, 2012.
12. Yang, F., X.-X. Zhang, X. Ye, and Y. Rahmat-Samii, "Wide-band E-shaped patch antennas for wireless communications," *IEEE Transactions on Antennas and Propagation*, Vol. 49, 1094–1100, 2002.
13. Islam, M. T., M. N. Shakib, and N. Misran, "Broadband E-H shaped microstrip patch antenna for wireless systems," *Progress In Electromagnetics Research*, Vol. 98, 163–173, 2009.
14. Bhardwaj, S. and Y. Rahmat-Samii, "A comparative study of C-shaped, E-shaped, and U-slotted patch antennas," *Microwave and Optical Technology Letters*, Vol. 54, 1746–1757, 2012.
15. Wang, Y. J., C. K. Lee, and N. C. Karmakar, "A novel microstrip patch antenna for 3G IMT-2000 mobile handsets," *Microwave and Optical Technology Letters*, Vol. 31, 488–491, 2001.
16. Bimpas, M. and N. Uzunoglu, "Development of a broadband E-shaped ground penetrating microstrip radiator combining microstrip resonators and a slotted ground plane," *Microwave and Optical Technology Letters*, Vol. 44, 172–176, 2005.
17. Deshmukh, A. A. and K. P. Ray, "Analysis of broadband Psi $\Psi$)-shaped microstrip antennas," *IEEE Antennas and Propagation Magazine*, Vol. 55, 107–123, 2013.
18. Sim, C.-Y. D. and T.-Y. Han, "Compact designs of a shorted triangular patch antenna with a V-slot," *Microwave and Optical Technology Letters*, Vol. 49, 34–37, 2007.
19. Shanmuganantham, T. and S. Raghavan, "Design of a compact broadband microstrip patch antenna with probe feeding for wireless applications," *International Journal of Electronics and Communication*, Vol. 63, 653–659, 2009.
20. IE3D Simulation Software, Version 14.05, Zeland Software Inc., USA, 2008.