Broadband E-Shaped Microstrip Patch Antenna For Wireless Communication

Naresh Kumar Joshi[1], Kamal Kumar Verma[2]
Student[1], Assoc. Prof.[2]
[1](Department of Electronics & Communication Engg., R.I.E.T., Jaipur (Raj.), Email:nareshjoshi25@yahoo.com)
[2](Department of Electronics & Communication Engg., R.I.E.T., Jaipur (Raj.), Email:kkverma99@gmail.com)

ABSTRACT

This paper presents a single-patch broadband microstrip antenna: the E-shaped patch antenna on a single-layer foam substrate is investigated.. The broadband mechanism is explored by investigating the behavior of the currents on the patch. Bandwidth enhancement of the antenna is achieved by inserting two parallel slots into its radiating patch. The effects of the following design parameters: the slot length, width, and position are optimized to achieve a broad bandwidth. Finally, a 32% E-shaped patch antenna, resonating at wireless communication frequencies of 1.5 and 2.9 GHz, is designed. The antenna was designed using IE3D software.

Keywords ***-Broadband, E-shaped patch, microstrip antenna, slots, wireless communications.***

1. Introduction

Microstrip patch antennas are widely used because of their many advantages, such as the low profile, light weight, and conformity. They are being used in a large variety of applications such as radar, missiles, aircraft, satellite communications, mobile communication base stations and handsets, as well as in biomedical telemetry services. Many of these applications, or roughly most of them require a wide bandwidth, where this is not the case in a conventional microstrip antenna. Bandwidth enhancement of this particular antenna arises from the fact of this major operational disadvantage of having a very narrow bandwidth. Researchers have made many efforts to overcome this problem and many configurations have been presented to extend the bandwidth. The conventional method to increase the bandwidth is using parasitic patches. The parasitic patches are located on the same layer with the main patch. In [2], an aperture-coupled microstrip antenna is described with parasitic patches stacked on the top of the main patch. However, these methods typically enlarge the antenna size, either in the antenna plane or in the antenna height. With the rapid development of wireless communications, single-patch broadband antennas have attracted many researchers' attention [3]–[5]. In [6], the authors presented a U-slot microstrip antenna and demonstrated that its bandwidth could exceed 30%. In this paper, we present a novel single-patch broadband microstrip antenna: the E-shaped patch antenna. When two parallel slots are incorporated into the antenna patch, the bandwidth increases above 30%. Compared to the U-slot microstrip patch antenna, the E-shaped patch antenna is simpler in construction. By only adjusting the length, width, and position of the slots one can obtain satisfactory performances. Some experimental results prove the validity of this design. The method of moments [7] with the vector triangular basis function [8] is used for analysis, as well as IE3D software.. Subsequently, a wide-band E-shaped patch antenna with 32% bandwidth is designed to cover both 1.5GHz and 2.9GHz. These ranges of frequencies are very desirable in modern wireless communications.

2. Antenna Geometry

The antenna geometry is shown in Fig.1. The antenna has only one patch, which is simpler than traditional wide-band microstrip antennas. The patch size is characterized by L, W, h and it is fed by a coaxial probe at position d_p. To expand the antenna bandwidth, two wide slits have the same length *l* and the same width w_1 and are inserted at the bottom edge of the patch. The separation of the two wide slits is *w*2 and the two slits are placed symmetrically with respect to the patch's centerline (*y* axis). There are only three parameters (l, *w*1, *w*2) for the wide slits used here. Along the patch's centerline, a probe feed at a distance *d*p from the patch's bottom edge can be located for good excitation of the proposed antenna over a wide bandwidth. The topological shape of the patch resembles the letter "E," hence the name E-shaped patch antenna. The E-shaped patch is formed by inserting a pair of wide slits at the boundary of a microstrip patch. The slot length (l), width (w_1), and position are important parameters in controlling the achievable bandwidth.

.

3. Effect of Slots

The effect of the slots, most importantly, the amplitudes of currents around the slots are different at low resonant frequencies and high resonant frequencies. It means that the effects of the slots at these two resonant frequencies are different. This is the key reason why the slots can extend the bandwidth. At the high frequency, the amplitudes of the currents around the slots are almost the same as those at the left and right edges of the patch. The effects of the slots are not significant. The patch works like ordinary patch. Therefore, the high resonant frequency is mainly determined by the patch width, less affected by the slots. While at the low frequency, the amplitudes of the currents around slots are greater than those at high frequency. The slots congregate the currents and this effect can be modeled as an inductance. Due to this additional inductance effect, it resonates at a low frequency. Thus, this lower resonant frequency is mainly characterized by the slots. Now it can be concluded that the antenna width controls the higher resonant frequency while the slots control the lower resonant frequency. Because of the dual resonant character, this kind of microstrip antenna can achieve a wide bandwidth [1].

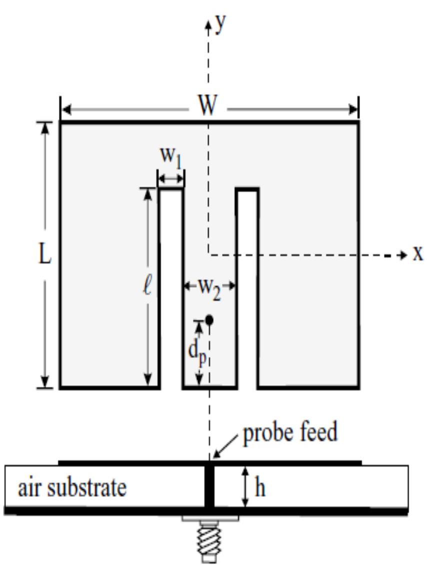

Figure.1: Geometry of E-Shaped Patch Antenna [11].

4. Results and Discussion

In this section, a broadband E-shaped patch antenna for wireless communications is characterized in detail. The results of this E-shaped patch antenna are shown figure 2 and 3. The S_{11} and Smith chart is obtained by IE3D software. From the figure, one can observe that the E-shaped patch antenna resonates at 1.5GHz and 2.9 GHz. These frequencies are chosen because they are useful frequencies in modern wireless communications. The E-shaped patch antenna has a wide bandwidth of 32%. The Slots play an important role to control the broadband behavior of the E-shaped patch antenna. There are three parameters to characterize the slots, namely slot length, slot position, and slot width. When the slot length is small, the antenna only has one resonant frequency. When the slot length increases, another lower resonant frequency appears. The longer the slot length, the lower the second resonant frequency. In brief, the slot length is an important parameter to characterize the resonant frequencies of the E-shaped patch antenna. When slot position is small, the S_{11} at lower frequencies does not match well. When becomes larger, the two resonant frequencies become distinct and a broadband match is obtained.

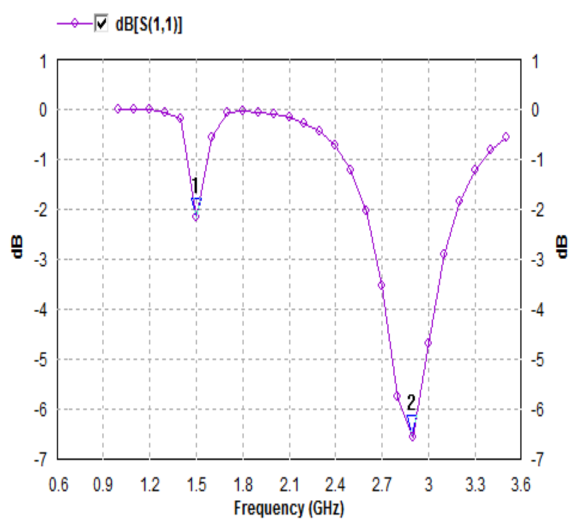

Figure.2: S_{11} for E-Shaped Patch Antenna (f = 1.5GHz and 2.9GHz).

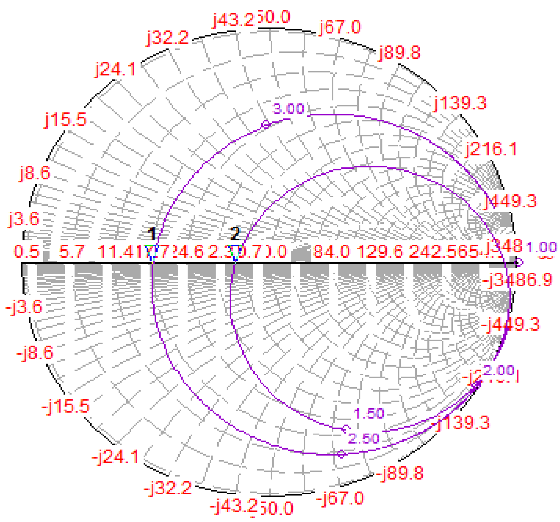

Figure.3: Smith Chart for E-Shaped Patch Antenna (*f* = 1.5GHz and 2.9GHz).

5. Conclusion

A novel technique for enhancing bandwidth of a patch antenna has been proposed. Two parallel slots are incorporated in the rectangular microstrip antenna such that it closely resembles a Slotted E shape. The antenna is successfully designed and it also attains a bandwidth of about 32 %. Finally, a 32% bandwidth E-shaped patch antenna, applicable to modern wireless communication frequencies of 1.5 to 2.9 GHz, is designed and characterized in detail. From the analysis of simulated results it can be verified that the antenna is best suitable for s band frequency operations.

REFERENCES

[1] Fan Yang, Xue-Xia Zhang, Xiaoning Ye, and Yahya Rahmat-Samii *"Wide*-Band E-Shaped Patch Antennas for Wireless Communications" *IEEE Trans. Antennas Propag., vol. 49, no. 7*, JULY 2001.

[2] D.M. Pozar,"Microstrip antenna coupled to a microstrip-line," *Electron. Lett., vol.21, no.2*, pp. 49–50, Jan. 1985.

[3] K.L.Virga and Y.Rahmat-Samii, "Low profile enhanced-bandwidth PIFA antennas for wireless communications packaging," *IEEE Trans. Microwave Theory Tech., vol. 45*, pp. 1879–1888, Oct. 1997.

[4] I. Papapolymerous, R. F. Drayton, and L. P. B. Katehi, "Micromachined patch antennas," *IEEE Trans. Antennas Propagat., vol. 46*, pp. 275–283, Feb. 1998.

[5] N. Herscovici, "New considerations in the design of microstrip antennas," *IEEE Trans. Antennas Propagat., vol. 46*, pp. 807–812, June 1998.

[6] T. Huynh and K. F. Lee, "Single-layer single-patch wideband microstrip antenna," *Electron. Lett., vol. 31, no. 16*, pp. 1310–1312, Aug. 1995.

[7] E. H. Newman and P. Tulyathan,"Analysis of microstrip antennas using moment methods,"*IEEE Trans. Antennas Propagat., vol. AP-29*, pp. 47–53, Jan. 1981.

[8] K. F. Tong, K. M. Luk, K. F. Lee, and R. Q. Lee, "Broadband U-slot rectangular patch antenna on a microwave substrate" *IEEE Trans. Antennas Propag., vol. 48, no. 6*, pp. 954–960, 2000.

[9] A. Khidre, K. F. Lee, F. Yang, and A. Elsherbeni, "Wideband circularly polarized E-shape patch antenna for wireless communications" *IEEE Antennas Propag. Mag., vol. 52, no. 5*, pp. 219–229, Oct. 2010.

[10] C. A. Balanis, *Antenna Theory: Analysis and Design* (2nd Edition, New York, John Wiley & Sons, 1997).

[11] K. L. Wong, *Compact and Broadband Microstrip Antennas* (New York: Wiley Inc., 2002.)

[12] G. Kumar and K. P. Ray, *Broadband Microstrip Antennas*. (Dedham, MA: Artech House, 2003).