Journal of Engineering Research and TECHNOLOGY, volume 1, issue 1, March 2014

A Novel Elliptically Shaped Compact Planar Ultra-Wideband Antenna

Mohamed Ouda

Abstract— A low profile planar elliptically shaped antenna for ultra-wide band applications is presented. The antenna consists of a conducting patch, a dielectric substrate and a partial conducting ground plane. The patch has the shape of modified elliptical rings and excited using a rectangular edge-fed microstrip feed line. The antenna size is 45mm x 23mm. The impedance bandwidth of the antenna extends from 3.5 GHz to 10.6 GHz, thus meeting the UWB system requirement.

Index Terms— Elliptical rings, printed antenna, Ultra-wideband antenna.

I. INTRODUCTION

Ultra-Wideband radio systems use a bandwidth extending from 3.1 GHz to 10.6 GHz to transfer data consistent with the regulations of the Federal Communications Commission (FCC) [1]. Microstrip Patch Antennas (MPA) are attractive candidates for use in developing ultra-wideband (UWB) antennas for short-range high-speed wireless communication networks due to their interesting features such as low cost, small profile and conformability [2]. Good UWB antennas should have low return loss, suitable radiation pattern and high efficiency over all the bandwidth [3]. One of the challenges facing the development of UWB radios is developing antennas that meet the bandwidth requirements. The most straightforward way to improve the MPA bandwidth is to increase the patch-ground plane separation by using a thicker substrate [4], [5]. Thick substrates, however, support surface waves that can increase mutual coupling in antenna arrays and possibly degrade the radiation pattern [6]. The bandwidth of an MPA can also be improved by combining several resonant structures into one antenna, such as increasing the metallization layers, increasing the number of patches or adding extra components [7].

Many antenna configurations have been used in UWB antenna design, such as square, circular, elliptical, pentagonal and hexagonal shapes [8-11]. Multiple ring monopole antennas were introduced in [12] and [13]. Several multiple ring antennas with different ellipticity ratios and ring thickness were investigated in [14]. Nazlı et al. presented enhanced elliptical slotted planar dipole antenna design for UWB communication and impulse radar systems [15].
In this paper, a low profile patch antennas for ultra-wide band applications is presented. The patch consists of modified elliptical rings and excited using a rectangular edge-fed microstrip line. A partial conducting ground plane is used for the impedance bandwidth enhancement of the antenna.

II. ANTENNA DESIGN

The geometry of the proposed antenna is shown in figure 1. It consists of a printed modified elliptical ring excited by a rectangular edge-fed microstrip line, the substrate and a short ground plane. The partial conducting ground and the antenna symmetrical shape have been used for bandwidth improvement in [11]. The antenna was designed on Rogers RT/Duroid 5880LZ substrate with dielectric constant of ε_r =1.96, height of H =1.27mm, and a loss tangent of 0.0009. The substrate has a length of 45mm and a width of 23mm. The width of the partial conducting ground plane is 23mm and the length is 10mm.

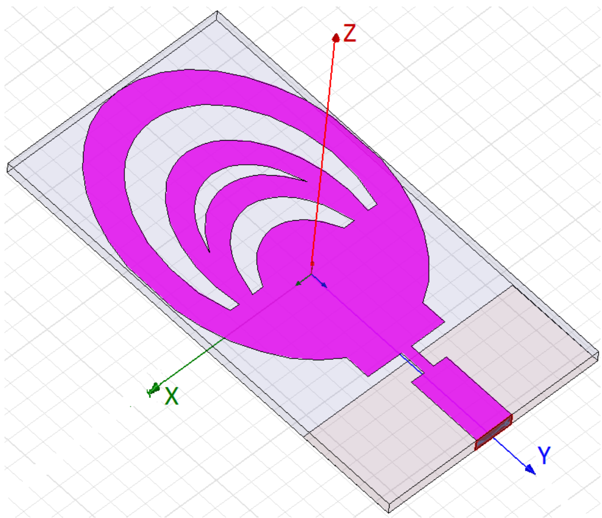


Figure 1. Antenna Geometry

• *M. Ouda is with the Electrical Engineering Department, Islamic University of Gaza, Gaza, Palestine.*

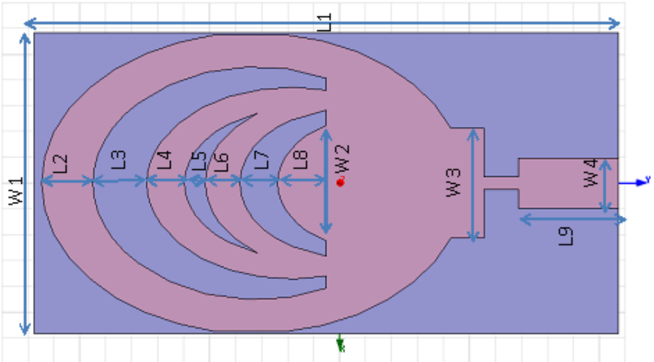


Figure 2. Top view of antenna configurations (L1 = 45, L2 = 3.97, L3 = 4.13, L4 = 2.9, L5 = 2, L6 = 2.65, L7 = 2.9, L8 = 4.9, L9 = 7.7, W1 = 23, W2 = 8.48, W3 = 3.92.

The top view of the modified elliptical ring patch configuration is shown in figure 2, where the dimensions of all parts are given in millimeters. The antenna was designed and simulated using ANSOFT's High Frequency Structure Simulator (HFSS V12) [16].
Figure 3 shows the variation of return loss with respect to the ground plane length. It is clear that changing the ground plane length affects the resonant frequency and the return loss of the antenna. The ground plane length was chosen to be 10mm.

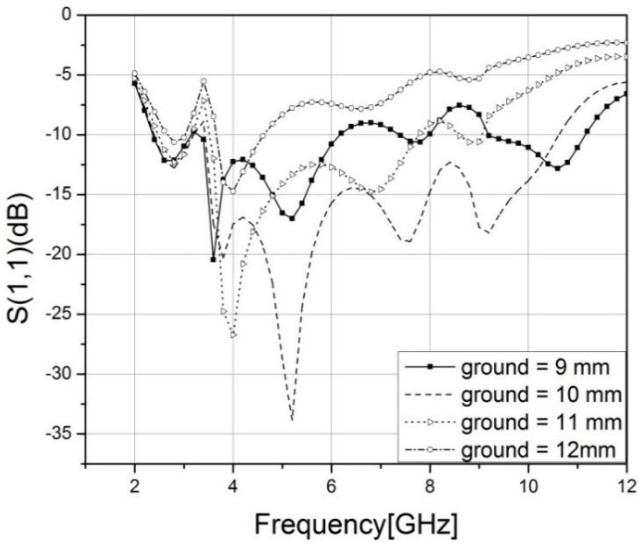


Figure 3. Simulated return loss for the different values of ground plane length

III. RESULT AND DISCUSSION

The simulated results of the return loss ($|S_{11}|$) and the standing wave ratio (SWR) of the antenna for the frequency range 2-12GHz are shown in figures. 4 and 5, respectively. It is shown in the figure that the antenna impedance bandwidth is more than 7.5 GHz, from 3.5GHz to 10.6GHz, thus meeting the FCC UBW requirement. Clearly the antenna is well matched across the frequency range without any need for a balun. Also, for the impulse system, the SWR level of the antenna is a critical parameter to avoid ringing effect. In order to avoid undesired ringing in the impulse system, the antenna input and the RF generator impedance should be matched over the wide frequency band. Therefore, the antenna is very useful for impulse systems due to its low-level SWR over the wide frequency band.

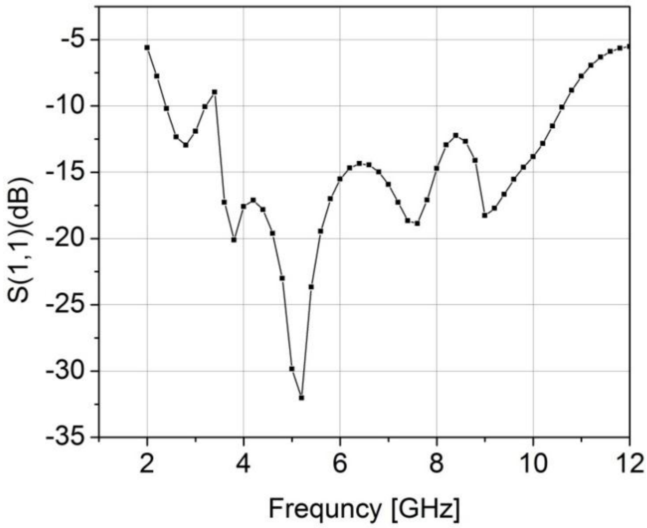


Figure 4. The return Loss

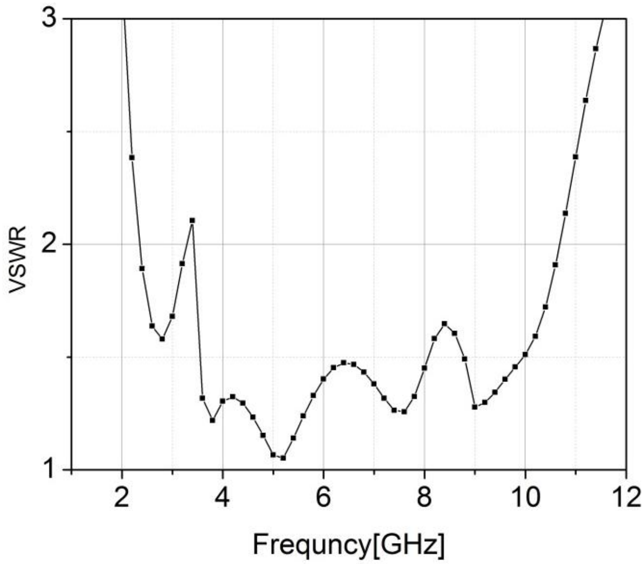


Figure 5. The simulated SWR.

The antenna 2D radiation patterns at 4, 6, 8, and 10 GHz in both E- and H-planes are shown in figures. 6 and 7, respectively. The radiation patterns of the antenna show that the antenna has quite stable radiation pattern over its entire frequency band.

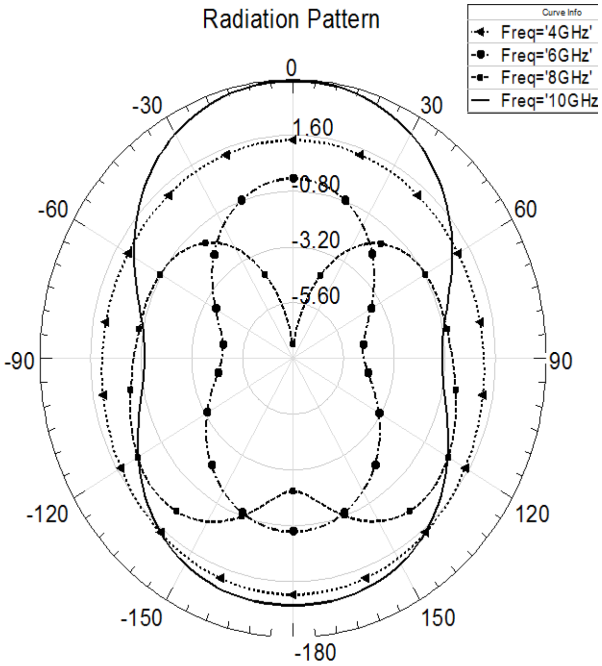


Figure 6. The 2-D polar radiation pattern at 4, 6, 8 and 10 GHz, and Phi=0^0

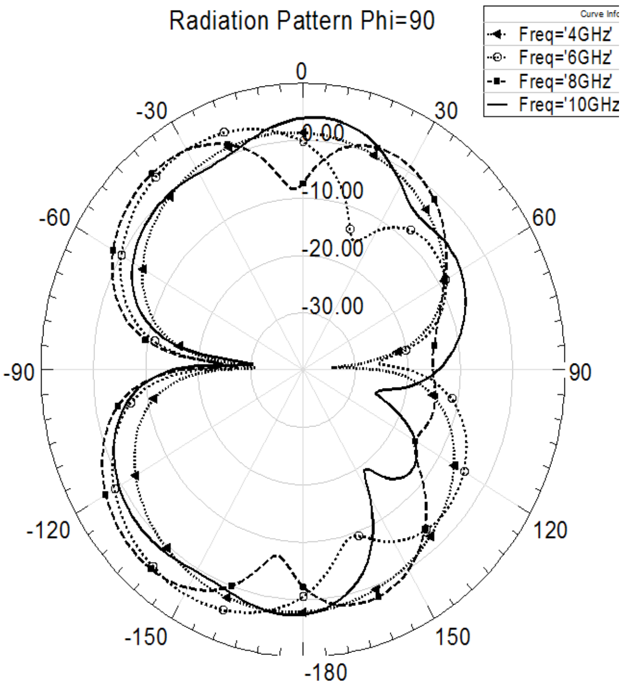
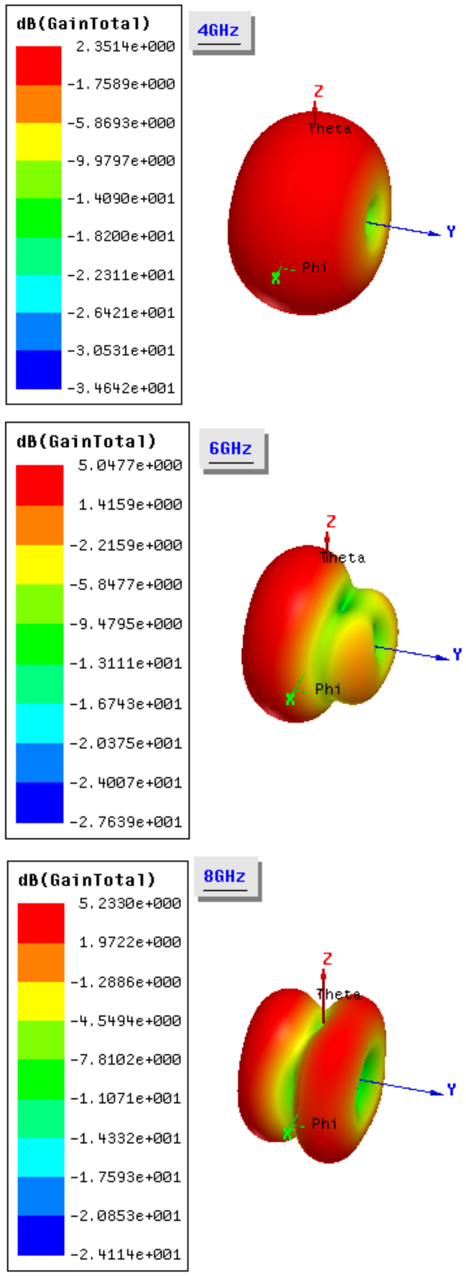


Figure 7. The 2-D polar radiation pattern at 4, 6, 8 and 10 GHz, and Phi=90^0



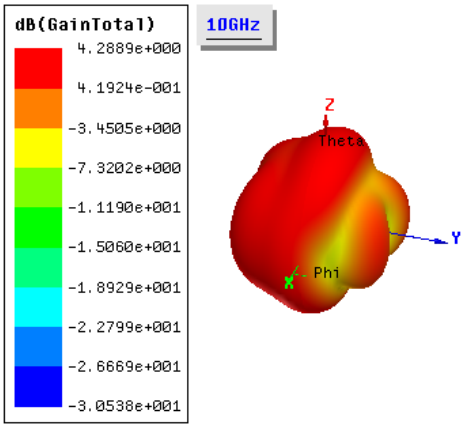


Figure 8. The 3-D radiation pattern at 4, 6, 8 and 10 GHz.

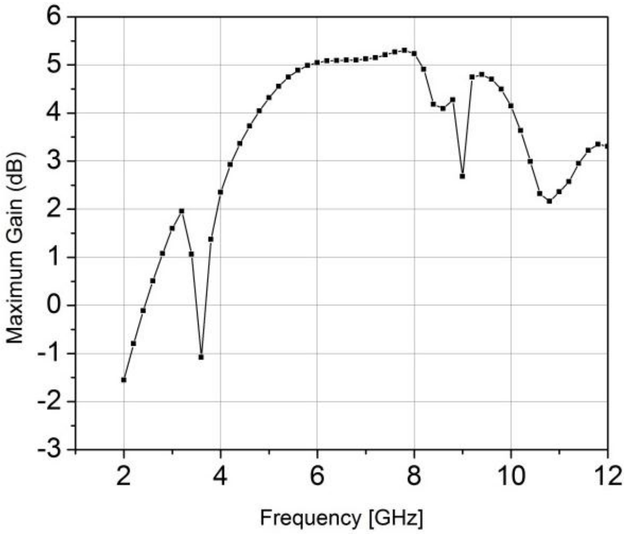


Figure 9. Simulated maximum antenna gain

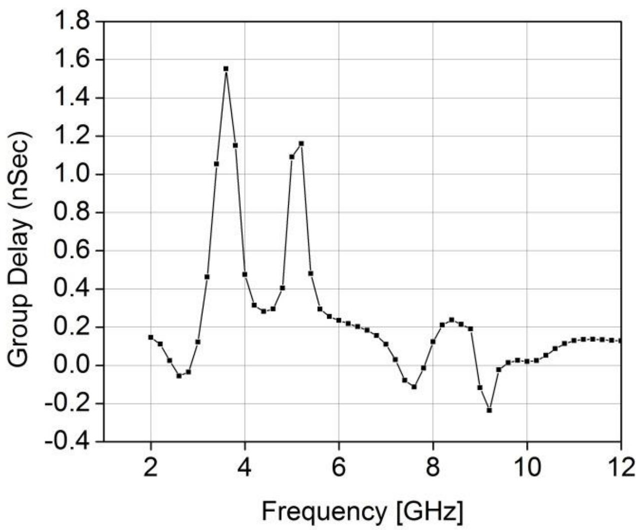


Figure 10. The antenna group delay

The 3D far-field radiation patterns of the antenna, at 4, 6, 8 and 10 GHz, are illustrated in figure 8.
Furthermore; the simulated maximum gain over the frequency range from 2 GHz to 12GHz is shown in figure 9 which shows that the antenna has acceptable gain in all of its bandwidth.
Group delay is an important parameter in UWB antenna design, which represents the degree of distortion of pulse signal. The antenna Group Delay is shown in figure 10. From the figure, it can be seen that the group delay variation is less than 0.25 ns for all frequencies above 5.8GHz, however; it increases to 1.5ns over a narrow segment of the bandwidth in the lower frequency region.

IV. CONCLUSION

A compact 45x23 mm low profile planar ultra-wide band patch antenna for ultra-wide band applications was proposed. The antenna was excited using a rectangular edge-fed microstrip line. A partial conducting ground plane was used to enhance the bandwidth of the antenna. The effect of the ground plane length was studied and a suitable length was selected for the antenna. The impedance bandwidth of the antenna is about 7.5 GHz, extending from 3.5 GHz to 10.6 GHz.

REFERENCES

[1] FCC, "Federal Communications Commission Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems," First Report and Order FCC, 02.V48, Apr. 2002.
[2] Y. Chen and Y. P. Zhang, "A planar antenna in LTCC for single package ultrawide-band radio," *IEEE Trans. Antennas Propagat*, vol. 53, No. 9, pp. 3089 – 3093, Sept. 2005.
[3] C.D. Zhao, "Analysis on the properties of a coupled planar dipole UWB antenna", *IEEE Antennas and Wireless Propagation Letters*, vol. 3, pp. 317-330, Dec. 2004.
[4] J. Bahl and P. Bhartia, *Microstrip Antennas*. Artech House, Inc., London, 1980.
[5] S. A. Hosseini, Z. Atlasbaf, and K. Forooraghi, "A New Compact Ultra Wide Band (UWB) Planar Antenna using Glass as Substrate," *Journal of Electromagnetic Waves and Applications*, vol. 22, No. 1, pp. 47–59, 2008.
[6] K. Bhattaacharyya and L. Shafai, "Surface wave coupling between circular patch antennas," *Electronic Letters*, vol. 22, No. 22, pp. 1198-1200, Oct. 1986.
[7] A. A. Abdelaziz, "bandwidth enhancement of microstrip antenna", *Progress In Electromagnetics Research*, PIER 63, pp. 311–317, 2006.
[8] H.G., "Bottom fed planar elliptical element UWB antennas". *IEEE Conf. on Ultra Wideband Systems and Technologies*, November, 2003, pp. 219–223.
[9] K. C. L. Chan, Huang, Y., and X. Zhu, "A planar elliptical monopole antenna for UWB applications". *IEEE Conf. on*

Wireless Communications and Applied Computational Electromagnetics, April 2005, pp. 182–185

[10] C. Y. Huang and W. C. Hsia, "Planar elliptical antenna for ultrawideband communications", *Electron. Lett.*, vol. 41, No. 6, pp. 296–297, Mar. 2005

[11] Y.-J. Ren and K. Chang, "Ultra-wideband planar elliptical ring antenna", *Electronics Lett.*, vol. 42, No. 8, April 2006.

[12] C. T. P. Song, P.S. Hall, H. Ghafouri-Shiraz, and D. Wake, "Multi-circular loop monopole antenna," *Electronics Lett.*, vol. 36, no. 5, pp. 391-393, Mar. 2000.

[13] C.T.P. Song, P.S. Hall, H. Ghafouri-Shiraz, "Multiband MultipIe Ring Monopole Antennas," *IEEE Trans. Antennas Propagat.*, vol. 51, no. 4, pp. 722-729, April 2003.

[14] A. Mirkamali, Peter S. Hall, and Mohammad Soleimani, "Elliptical Multiple Ring Monopole Antennas" *IEE Conf. on Wideband and Multi-band Antennas and Arrays*, IEE (Ref. No. 2005/11059), 7 Sept. 2005, PP. 123 – 127.

[15] H. Nazlı, E. Bıçak, B. Türetken, and M. Sezgin, "An Improved Design of Planar Elliptical Dipole Antenna for UWB Applications" *IEEE antennas and wireless propagation letters*, vol. 9, pp. 264-267, 2010.

[16] Ansoft Corporations, HFSS V.12- Software based on the finite element method.