Journal of Engineering Science and Technology Review 7 (3) (2014) 176– 179

JOURNAL OF
Engineering Science and Technology Review

www.jestr.org

Research Article

Design on X-band Wideband and High-gain Multi-layer Microstrip Antenna

Soufian LAKRIT* and Hassan AMMOR

Electronic and Communication Laboratory, EMI, Mohammed V University, Agdal, Rabat-Morocco

Received 8 November 2013; Accepted 16 July 2014

Abstract

In this paper, a wide-band and high-gain microstrip antenna with mullti-layer microstrip patch and an aperture-coupled feeding is proposed. The antenna has a condensed structure where the dimension is about 8.5mm by 7.5mm by 4.662mm leading to good bandwidths covering 8.05 GHz to 12.01 GHz (39.48%), and the gain is up to 5.23dB. The low expenses of this profile and its simple configuration allows for an its easy fabrication, with appropriation with wireless and satellite communication.

Keywords: Microstrip antenna, Multilayer, High gain, wide band, aperture coupled feed, X - band

1. Introduction

With the rapid development of modern Wireless Communication Technology, microstrip antenna is in researchers' good graces because of its advantages, such an low profile, light weight, high-gain, and simple structure antennas to assure reliability, mobility, and efficiency [1]. Indeed, Microstrip antenna satisfies such requirements. The key features of a micro-strip antenna are relative ease of construction, light weight, low cost and either conformability to the mounting surface or, an extremely thin protrusion from the surface. This antenna provides all the advantages of printed circuit techno-logy. These advantages of microstrip antennas make them popular in many wireless communication applications such as satellite communication, radar, medical applications, etc [2], where motivation was to find the relationship between the slot offset and the length with slot active conductance at the slot plan. Owing to the resonance behavior of the slotted array antenna at the broad wall of the waveguide, the impedance and pattern bandwidth is narrow at the design frequency. Recently, enhancement of impedance and pattern bandwidth for slotted arrays by adding a wide-band matching element at the impedance transformation plan [3]. Activities where motivation was to find the relationship between the slot offset and the length with slot active conductance at the slot plan [4]. The microstrip antennas are known by their narrow frequency band and disability to operate at high power levels of waveguide, coaxial line or even stripline. Therefore, the challenge in microstrip antenna design is to increase the bandwidth and gain [5]. Antenna arrays in the X-band have been widely reported in literature. More recent antenna arrays in the X-band range from patch antennas [6]-[8]. Researchers have proposed and investigated many techniques to overcome these major problems like slotted patch antennas, microstrip patch antennas on electrically thick substrate, probe feed stack antenna and the use of various feeding and impedance matching techniques and the use of multiple resonators [9], [10].

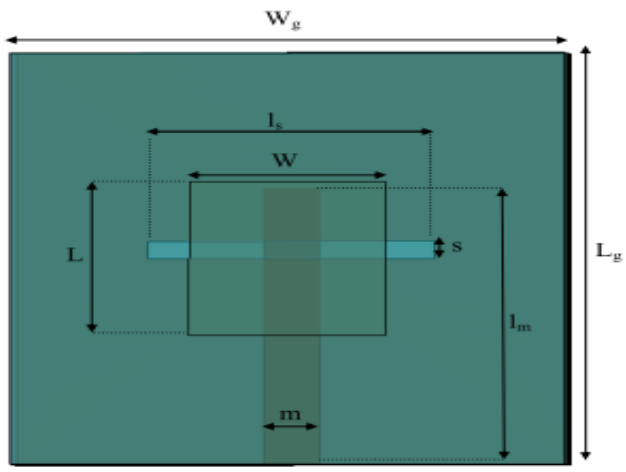
Several authors [2,8,11,12,13] have focused on technical the design multilayer microstrip patch antennas for X-band Application.

In this letter, a novel broadband multilayer patch antenna is presented. This antenna has several advantages; first, it is small and simple to manufacturing structure fed by a microstrip line over the substrate lower 50Ω impedance. The antenna design was performed using the Ansoft High Frequency Structure Simulator (HFSS).

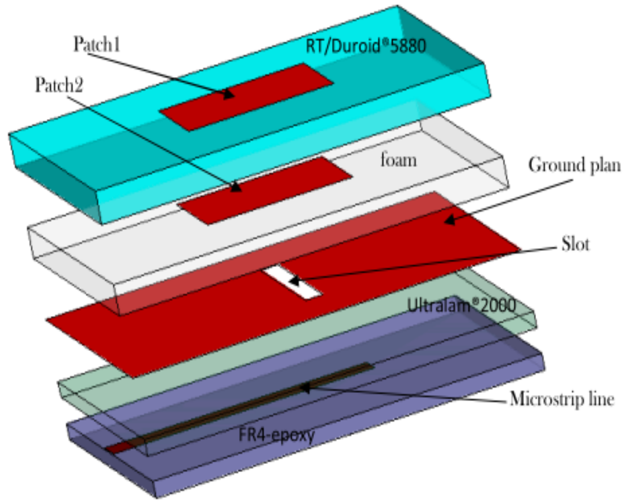
2. Antenna Design

Figure1 shows the geometry of the proposed antenna, as can be seen; this antenna element is formed by three dielectric substrate layers and foam layer. The first layer is RT/Duroid®5880 with the relative dielectric constant of 2.2 and thickness of 1.5mm, this is used for the patch1 layer. This is followed by an inexpensive plastic foam material (Rohacelle-®51 with ε_r=1.07 and h=1.5mm), this is used for the patch2 layer, it is used to enhance the antenna operational band-width. The second layer is An Ultralam-®2000 substrate of 0.762mm thickness with the relative dielectric constant of 2.50 is chosen for the feed layer. The third layer is used for feed line is the FR4-epoxy substrate with the relative dielectric constant of 4.4 and thickness of h2=0.8mm.

* E-mail address: lakritsoufian@gmail.com
ISSN: 1791-2377



(a) Top view



(b) Side view

Fig 1. Geometry of the proposed antenna.

3. Results and Discussion

All of the simulations are performed by software HFSS. Figure2 shows the reflection coefficient of the proposed antenna. The obtained result shows that the bandwidth at -10dB of this antenna is in the frequency range from 8.05 to 12.01 GHz, which covers the bandwidth of the X-band applications. Figure 3 shows the voltage standing wave ratio (VSWR) of the proposed antenna.

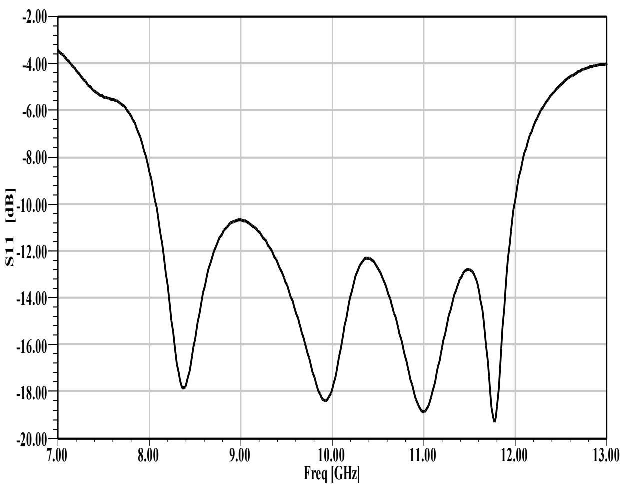


Fig 2. Reflection coefficient of the proposed antenna.

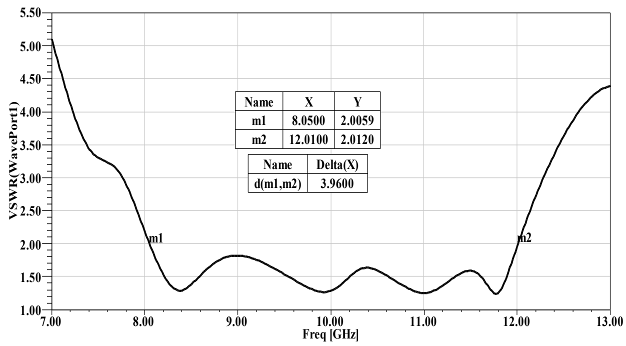
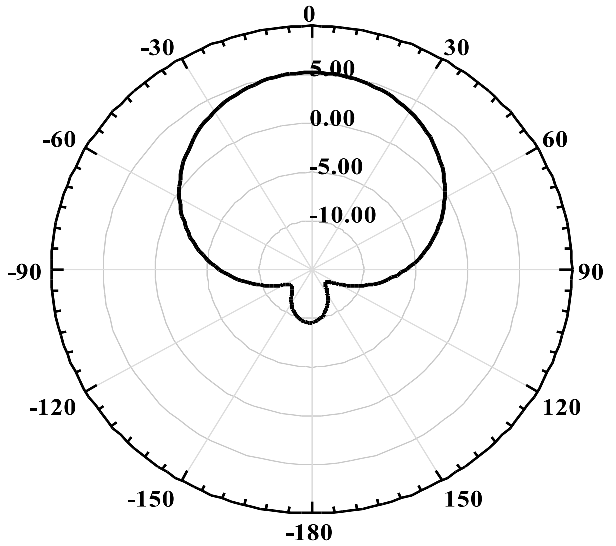
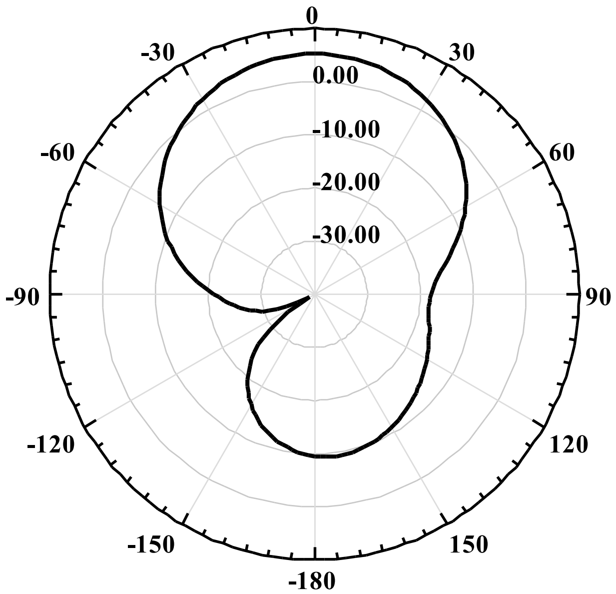


Fig 3. The VSWR of the proposed antenna.



(a)



(b)

Fig 4. Radiation patterns of the proposed antenna. (a)E-Plane, (b)H-Plane at 10GHz.

The simulated radiation patterns at 10 GHz is shown in Figures 4(a), 4(b) respectively. From the simulated results, the antenna presents a radiation above 5.3dB in a band from 9.58 to 10.27GHz of the operating band in H-plane and E-plane. The asymmetry in E-plane and H-plane is caused by the asymmetrical feed stub and the proposed antenna. For the symmetrical structure of the antenna along XZ plane, the symmetrical radiation in H plane is produced. The proposed antenna shows a simulated maximum gain in the broadside direction of 5.23dB at 10GHz.

Figures 5 and 6 allowing a visualization 2D radiation pattern for phi = 0° and 90° at the resonance frequency of 10 GHz. This formalism allows to immediately reporting the ability of the antenna to radiate evenly over the tape.

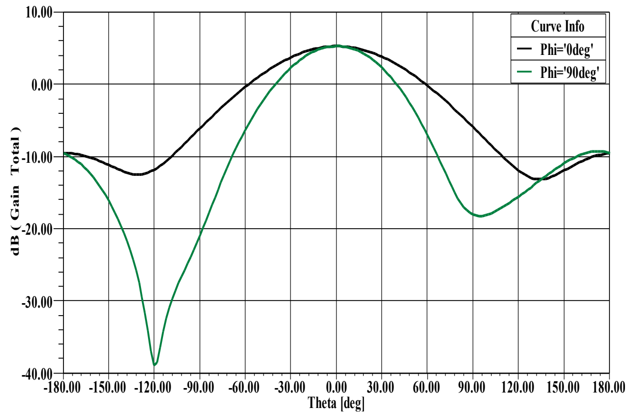


Fig 5. Gain pattern of the antenna at 10 GHz for phi = 0° & phi = 90°.

We note that the gain of the patch antenna is maximum and its value is 5.23 dB.

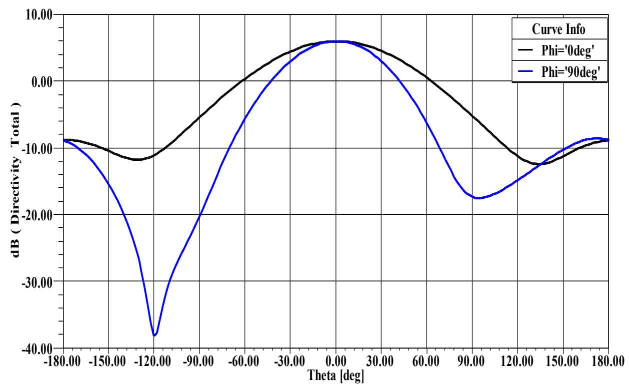


Fig 6. Directivity of the antenna at 10 GHz for phi = 0° & phi = 90°.

We note that the directivity of the antenna patch is maximum and its value is 5.94 dB. As shown in figure 7, the average peak gain of the proposed antenna is almost 5.23 dB. The gain variation across the operating band is 3dBi. It is almost higher than other antenna design.

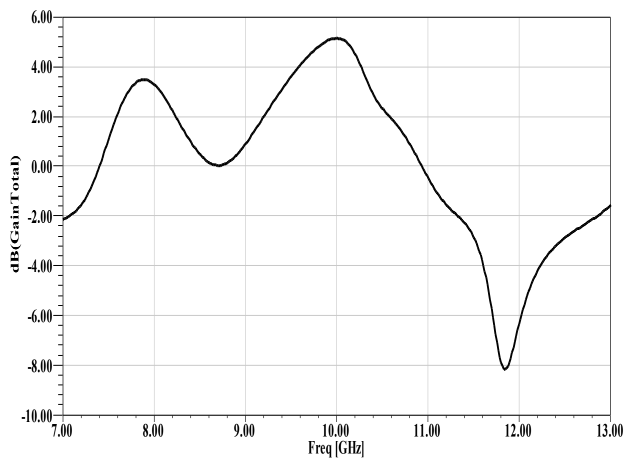


Fig 7. Gain vs frequency response of the proposed antenna.

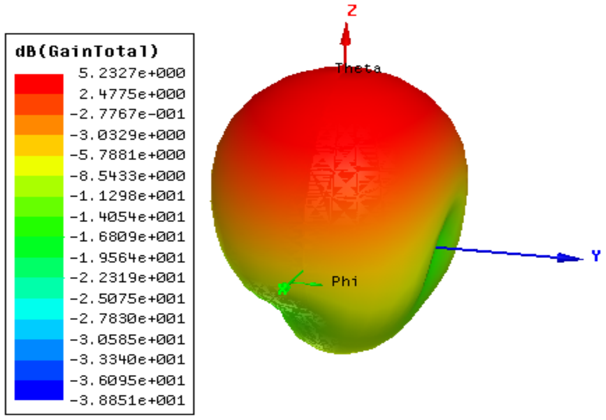
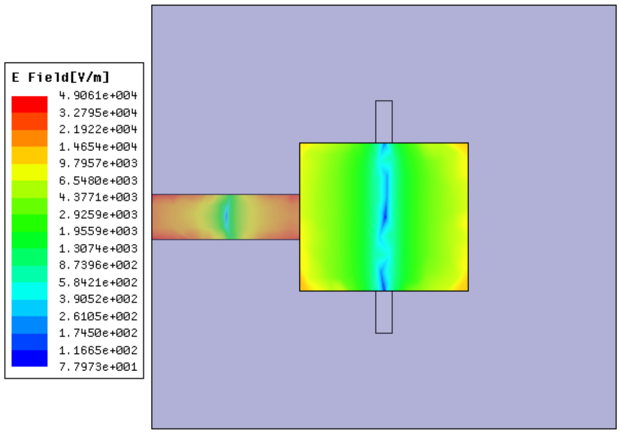
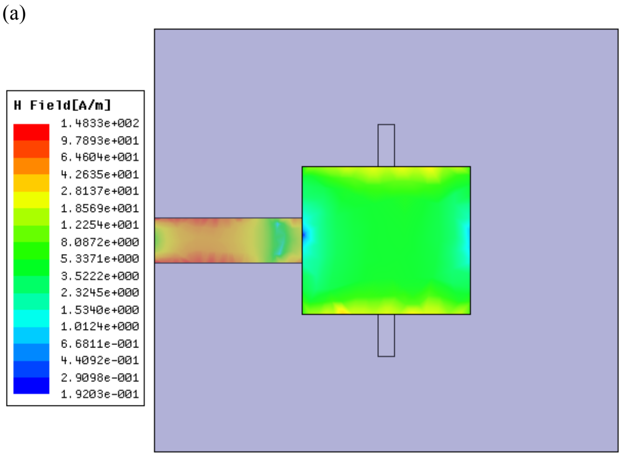


Fig 8. 3D Gain total of the proposed antenna.



(a)



(b)

Fig 9. (a) E-field distribution. (b) H-field distribution

Figure 8 shows that the radiation patterns of the antenna are almost omnidirectional.

Figure 9(a) shows the electric field distribution. The maximum value of the E-field obtained is 4.9 10^4 V/m. The simulated intensity of a magnetic field in the patch is shown in figure 9(b). The maximum value of the H-field obtained is 1.48 10^2 A/m.

4. Conclusion

In this paper, an X-band multilayered planar microstrip antenna is presented. The antenna achieves extremely wide frequency bandwidth and good radiation characteristics in terms of beam pattern, front-to-back ratio. By simulation, the antenna demonstrated a bandwidth of 39.48% for a VSWR<2 and the gain is up to 5.23dB. According to the results obtained, using the design method presented in this paper can extremely increase the impedance bandwidth of an X-band microstrip antenna. The method can be easily revised and extended for the design of other types of wide-band multi-layered structures antennas.

References

1. D. M. Pozar and D. H. Schaubert: "Microstrip Antennas", New York: IEEE Press, 1995.
2. M. T. I. Huque, et al: " Design and Simulation of a Low-cost and High Gain Microstrip Patch Antenna Arrays for the X-band Applications", in International Conference on Network Communication and Computer ICNCC, New Delhi, India., March 21-23, 2011.
3. A., Derneryd, and R., Petersson: "Band-width characteristics of monopuls slotted wave guide antennas". 4th Int. Conf. on Antennas and Propagation, (ICAP 85), Coventry, United Kingdom, pp. 27–30, 1985.
4. L. Josefsson and P. Persson: "Conformal Array Antenna Theory and Design", New York: IEEE Press, Wiley-Inter-science, 2006.
5. R. Mailloux, et al. "Microstrip array technology", Antennas and Propagation, IEEE Transactions on, vol. 29, pp. 25-37, 1981.
6. P. Sharma and R. A. Rodriguez-Solis, " Dual-polarized X-band microstrip patch sub-array for Off-the-Grid radar array antenna", in Proc.IEEE Int. Symp. on Antennas and Propagation, pp.577–579, 2011.
7. K. M. Ho, S. Donghyup, and G. M. Rebeiz, "X-band phased array development on teflon laminates with CMOS RFIC receivers", in Proc. IEEE Int. Symp. on Antennas and Propagation, pp.565–568, 2011.
8. S. D. Keller and S. Weiss, "Microstrip patch antenna array for a scalable X-band radar system ", in Proc. IEEE Antennas and Propagation Society Int. Symp, pp. 1–4, 2010.
9. A., Ramadan, K.Y. Kabalan, A. El-Hajj, S. Khoury and M. Al-Husseini, "A reconfigurable U notch microstrip antenna for wireless applications", Progress In Electromagnetics Research, PIER, 93,pp. 355-367, 2009.
10. Li, H., B.Z. Wang and W. Shao, "Novel broadband reflect array antenna with compound-cross-loop elements for millimeter-wave application", Journal of Electromagnetic Wave and Applications, pp. 1333-1340, 2007.
11. Claudius, Löcker.,Thomas, F. Eibert, " Unidirectional Radiation Efficient Sta-cked Aperture Antenna for X-Band Application", Journal Antennas and Wireless Propagation Letters, IEEE , 7, pp. 264-266, 2008.
12. M. Wnuk, R. Przesmycki, L. Nowo-sielski, and M. Bugaj, "Multilayer Microstrip Antenna on Flat Base in the X Band (8.5 GHz–12GHz)", Progress in Electromagnetics Research Symposium, PIERS ONLINE, 7,pp. 216-220, 2011.
13. Md. Tanvir Ishtaique-ul Huque, Md. Kamal Hosain, Md. Shihabul Islam, and Md. Al-Amin Chowdhury, "Design and Performance Analysis of Microstrip Array Antennas with Optimum Parameters for X-band Applications", International Journal of Advanced Computer Science and Applications, IJACSA, Vol. 2, N° 4, pp. 81-87, 2011.