ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DESIGN OF ULTRA WIDEBAND SMALL CIRCULAR PATCH ANTENNA FOR WIRELESS COMMUNICATION

Soufian Lakrit and Hassan Ammor
Electronic and Communication Laboratory, Mohammed V University Agdal, UM5A EMI- Avenue Ibnsina, Agdal, Rabat, Morocco
E-Mail: lakritsoufian@gmail.com

ABSTRACT

This paper presents the design of an ultra-wideband Circular microstrip patch antenna for (UWB) communications. In this structure there is a small Circular patch consists of a partial ground plane and fed by a 50 Ω microstrip line. The proposed antenna can achieves a wide bandwidth from 2.72 GHz to 12.17 GHz with VSWR < 2 with stable and bi-directional radiation pattern. The simulation of this antenna has been performed by using Ansoft High Frequency Structure Simulator (HFSS) and Computer Simulation Technology- Microwave Studio (CST).

Keywords: microstrip, ultra-wideband (UWB), VSWR, HFSS, CST.

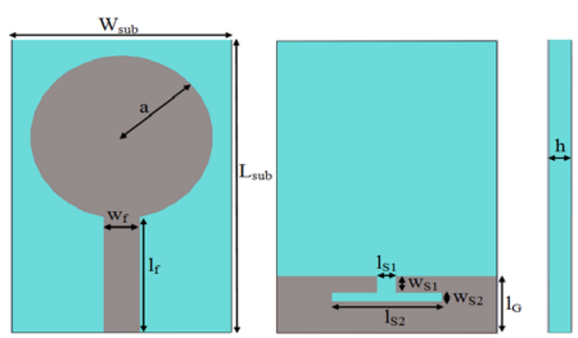
1. INTRODUCTION

With the rapid developments in broadband wireless communications and the great number of commercial and military applications, necessitate new types of antennas, which can support higher bit rates. 4G mobile terminals are gaining immense popularity thanks to their advanced and user-friendly features. Also, designing new compact antennas with good characteristics applied for 3G mobile terminals is quite necessary although number of similar studies had been conducted so far[1], since the Federal Communications Commission(FCC) allowed 3.1 to 10.6 GHz or the signal bandwidth is more than 500MHz unlicensed band for UWB communication [2]. UWB also have wide applications in short range and high speed wireless systems, such as ground penetrating radars, medical imaging system, high data rate wireless local area networks WLAN (5.15–5.35 and 5.725–5.825 GHz), downlink of X-band satellite communication systems (7.25–7.75 GHz) and ITU (8.025–8.4 GHz). Many techniques have already been applied to design wideband antennas for different applications, one of which to increase the bandwidth. Since microstrip patch antennas inherently have narrow bandwidth characteristic, there have been numerous techniques developed for bandwidth enhancement in order to achieve the UWB characteristics[3]. These antennas have been discussed in the literature, for instance, U-slot stacked patch antennas [4], triangle Circular fractal antenna [5], H-slot antenna [6], E-shaped patch antenna [7]. Other techniques employed to increase the bandwidth of antennas include meandered ground plane [8], slot loading [9], meandering slots [10], tulip-shaped monopole antenna [11] and T-slot in the radiating element [12].

In this paper, a novel small Circular patch antenna is proposed, This structure present a wide bandwidth and miniaturized dimensions, sufficient impedance bandwidth and highly stable and bi-directional radiation pattern is obtained. The planar antenna consists of a circular shaped radiating patch and partial ground plane with a T-shaped slot on the upper edge to cause a broad bandwidth from 2.76 to 11.71 GHz frequency. The antenna structure is flat, and its design is simple and straightforward. Details of the proposed design are presented and discussed in this paper. The proposed antenna design and performances are analyzed by using Ansoft High Frequency Structure Simulator (HFSS) and Computer Simulation Technology- Microwave Studio (CST).

2. ANTENNA GEOMETRY AND DESIGN

Figure-1 illustrated the configuration of the proposed antenna, which consist of a circular patch, a partial ground plane and a T-shaped slot on the ground plane. The antenna, which has a compact dimension of 5mm The radius a, is printed in the front of a FR4 substrate of thickness 1.58mm and relative permittivity 4.4. The dimension of partial ground plane, which is printed in the bottom side of the substrate, is chosen to be $12\times3.5mm^2$ in this study. The bottom of the patch is connected by a microstrip line, which is fed by a 50Ω coaxial probe from the side of the antenna. The microstrip line was etched on the same side of the substrate as the radiator. The antenna has the following parameters: L_{Sub}=18mm, W_{Sub}=12mm, a = 5mm, L_G = 3.5mm, l_f= 7mm, W_f = 2mm, h=1.58mm, w_{S1}=l_{S1}=1mm, w_{S2}=0.5mm, l_{S2}=6mm.



Top view Bottom view side view

Figure-1. Geometry of proposed antenna.

3. RESULTS AND DISCUSSIONS

In this section, the circular patch antenna with various design parameters is constructed, and the numerical results of the input impedance and radiation characteristics are presented and discussed. The simulated results are obtained using the Ansoft simulation software high frequency structure simulator (HFSS).

Figure-2 shows the reflection coefficient of this antenna according to the frequency. This result shows the presence of a resonance frequency at 8.28GHz with a level of S_{11} parameter at 24.61-dB. Bandwidth measured at 10-dBranges from 2.72GHz to 12.17GHz, presented a width of 9.45GHz.

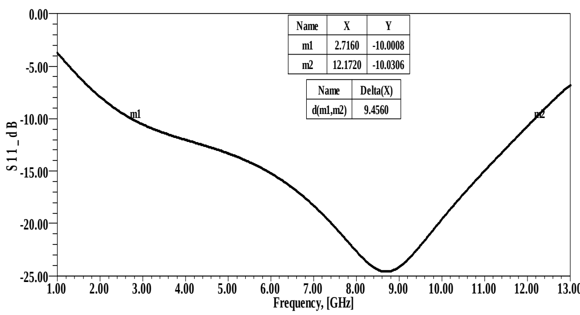


Figure-2. Simulated reflection coefficient S_{11} against frequency.

To validate our use of design software HFSS, we designed and simulated the same structure as CST whose numerical analysis is based on the method of the Finite Integration Technique (FIT). Figure-3 illustrates the reflection coefficient obtained by both simulation tools. We note a good agreement between the simulated results. There is a slight difference if we consider the resonant frequency, that is, in terms of bandwidth results are very comparable. As shown in Table-1.

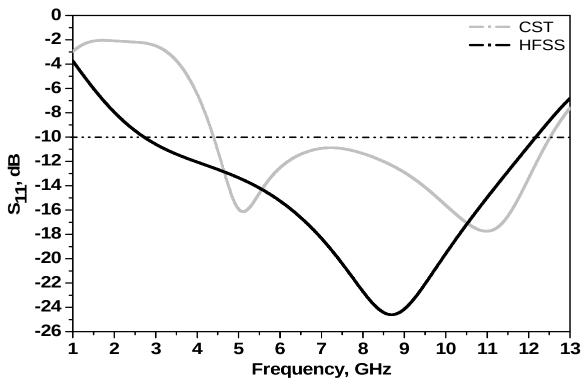


Figure-3. Comparison between the simulated S_{11} for the proposed antennas with HFSS and CST.

Table-1. Comparison results between HFSS and CST.

	Bandwidth(GHz)	**Resonant frequency**	**Level S_{11}(dB)**
HFSS	2.72 - 12.17	9.45 GHz	-24.61
CST	4.09 – 12.6	5GHz 11.25 GHz	-16.14 -17.75

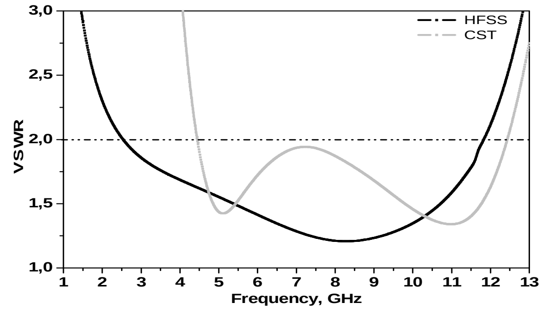
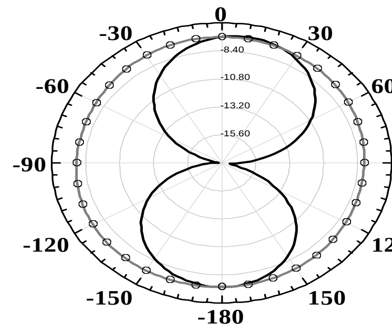
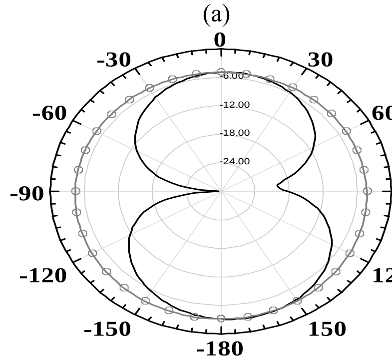


Figure-4. Comparison between the simulated VSWR for the proposed antennas with HFSS and CST.

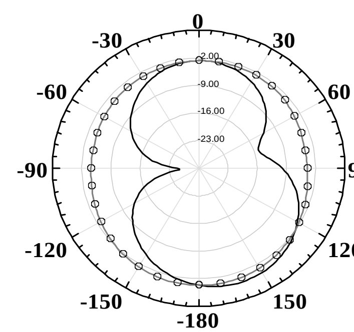
Figure-4 shows the simulated VSWR characteristics of the proposed antenna obtained by the two tools for simulation. We notice good agreement between the simulated results.



(a)



(b)



(c)

Figure-5. E- and H-field patterns at different frequencies a-3.5GHz, b-5.86GHz and c-10GHz.

VOL. 10, NO. 4, MARCH 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Figure-5 shows the radiation patterns of the proposed antenna at three frequencies of 3.5GHz, 5.86GHz and 10GHz. It is observed that at lower frequencies both the E- and H-plane field patterns are approximately bidirectional and the antenna has a main beam in the broadside direction. As the frequency increases, higher order current modes are excited and the radiation patterns becomes slightly directional. However a stable and symmetric the radiation patterns are observed over the entire operating band of the proposed antenna which is similar to a typical monopole antenna [17].

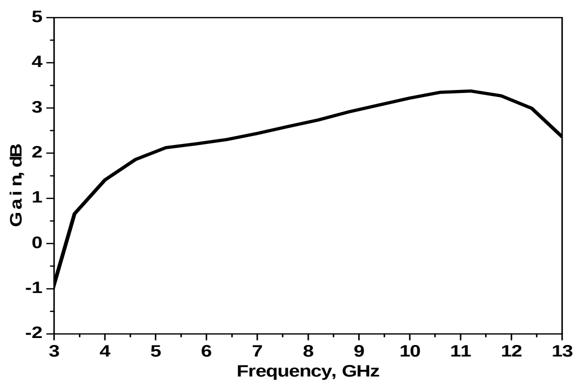


Figure-6. Gain in dB of proposed antennas against frequency.

Figure-6 shows the antenna gain in a frequency range from 1GHz to 13 GHz. The maximum gain is 3.55 dBi at 11.5GHz. The 3D radiation pattern of the proposed antenna is shown in Figure-7.

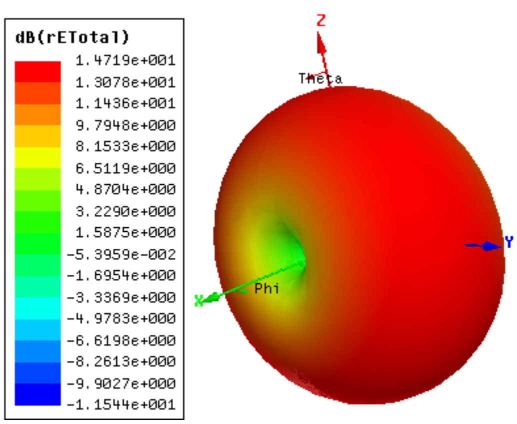


Figure-7. 3D Radiation pattern of the radiating patch at 5.86 GHz.

4. CONCLUSIONS

A novel small compact circular microstrip patch antenna has been proposed for UWB applications. We showed that by embedding a pair of T-slots with a proper dimension and position in the partial ground plane, a wide impedance bandwidth from 2.72GHz to 12.17GHz (9.45GHz) with VSWR<2 is achieved. In addition, the antenna is compact and can cover the whole frequency band of 5.8GHz-band RFID systems, WLAN, ITU, X-band satellite communication systems and European-standard UWB systems; it should be a promising candidate for such applications.

REFERENCES

[1] Dalia M. Elsheakh. and Esmat A. Abdallah. 2014. Ultrawideband Vivaldi Antenna for DVB-T, WLAN,and WiMAX Applications. International Journal of Antennas and Propagation. Volume 2014, Article ID 761634, pp: 1-7, http://dx.doi.org/10.1155/2014/761634.

[2] 2002. Federal Communications Commission Revision of Part 15 of the Commission's Rules Regarding Ultra Wideband Transmission System from 3.1 to 10.6 GHz. In Federal Communications Commission. Washington. DC: ET-Docket, pp. 98–153, FCC.

[3] Chia Ping Lee. and Chandan Kumar Chakrabarty. 2011. Ultra Wideband Microstrip Diamond Slotted Patch Antenna with Enhanced Bandwidth. Int. J. Communications, Network and System Sciences, vol 4, No 7, pp : 468-474. doi:10.4236/ijcns.2011.47057.

[4] Koray Sürmeli and Bahattin Türetken. U-Slot Stacked Patch Antenna Using High and Low Dielectric Constant Material Combinations in S-band. 30th URSI General Assembly and Scientific Symposium, URSIGASS, 13-20 Aug. 2011 Istanbul, Turkey. 10.1109/URSIGASS.2011.6050299

[5] Raj Kumar., Dhananjay Magar and K. Kailas Sawant. 2012. On the design of inscribed triangle circular fractal antenna for UWB applications. AEU - International Journal of Electronics and Communications. vol 66, No 1, pp: 69-75. doi:10.1016/j.aeue.2011.05.003.

[6] Soufian Lakrit., Hassan Ammor. and Jaouad Terhzaz. 2013. Design of H-slot Patch Antenna for Ultra Wideband. European Journal of Scientific Research. Vol. 106, No. 2, pp.224-228.

[7] B.-K. Ang. and B.-K. Chung. 2007. A wideband e-shaped microstrip patchantenna for 5–6 GHz wirelesscommunications. Progress in Electromagnetics Research, PIER. Vol. 75, pp. 397–407.

[8] Rezaul AZIM., Mohammad Tariqul ISLAM. and Ahmed Toaha Mobashsher. Ultra-wideband Antenna with Band-notches for Lower and Upper WLAN. PRZEGLĄD ELEKTROTECHNICZNY, Issue 01a/2013.

ARPN Journal of Engineering and Applied Sciences

[9] Kiran, K.U. Vani, R.M., Ravi, R.M., Hunagund, P.V. 2006. Slot-loaded Rectangular Microstrip Antenna with Meandering Slots in the Ground Plane for Compact Broadband Dual-frequency Operation. Antennas, Propagation & EM Theory, 2006. ISAPE '06. 10.1109/ISAPE.2006.353480.

[10] Prabhakar, H.V., Kummuri, U.K., Yadahalli, R.M., Munnappa, V. 2007. Effect of various meandering slots in rectangular microstrip antenna ground plane for compact broadband operation. Electronics Letters, vol 43, No. 16, pp. 848-850.

[11] D. C. Chang., J. C. Liu. and M. Y. Liu. 2006. A novel tulip-shaped monopole antenna for UWB applications. Microw. Opt. Technol. Lett. vol. 48, pp. 307–312.

[12] Radouane Karli., Hassan Ammor., Jaouad Terhzaz., Mohamed Chaïbi. and Á.Mediavilla Sánchez. 2015. Design and construction of miniaturized UWB microstrip antenna with slots for UWB applications", MICROWAVE and OPTICAL TECHNOLOGY LETTERS. Vol. 57, Issue 2, pp. 460-463, February.

[13] X. H. Wu. and Z. N. Chen. 2005. Comparison of planar dipoles in UWB applications. IEEE Trans. Antennas Propag. vol. 53, pp. 1973–1983.

[14] X. H. Wu. and A. A. Kishk. 2008. Study of an ultrawideband omnidirectional rolled monopole antenna with trapezoidal cuts. IEEE Trans. Antennas Propag. vol. 56, pp. 259–263.

[15] X. H. Wu., Z. N. Chen. and N. Yang. 2004. Optimization of planar diamond antenna for single-based and multiband UWB wireless communications. Microw. Opt. Technol. Lett. vol. 42, pp. 451–455.

[16] Azim R., Islam M. T., Misran N. and Mobashsher A. T. 2011. Compact UWB planar antenna for broadband applications. Informacije MIDEM. Vol. 41, No.1, pp. 37-40.

[17] Soufian Lakrit and Hassan AMMOR. 2014. Design of Square Microstrip Antenna Using T-Shaped Notch in the Ground Plane for Ultra Wideband Applications. International Journal of Innovation and Scientific Research. vol. 7, no. 1, pp. 1–4.

[18] Azim R., Islam M. T. and Misran N. 2011. Ground modified double sided printed compact UWB antenna, Electron. Lett. Vol. 47, No. 1, pp. 9-11.