Journal of Engineering and Applied Sciences 12 (Special Issue 4): 6699-6702, 2017
ISSN: 1816-949X
© Medwell Journals, 2017

Efficient Design of U-Shape Microstrip Patch Antenna for RF Energy Harvester Application

[1]S. Parasuraman and [2]G.P.R. Ramesh
[1]St. Peter's University,
[2]Department of ECE, St. Peter's University, 600054 Chennai, Tamil Nadu, India

Abstract: This study presents the efficient design of U-shape micro strip patch antenna for the application of RF energy harvesting. The U-shape microstrip antenna has become a speedily growing area with their application like mobiles and satellite communication. Microstrip antennas usually have a radiate conducting patch on a grounded microwave substrate. In the previous decade microstrip antennas caught the interest of a lot of designers as they have several attractive features as low profile, light weight, its ease of fabrication and allowing both linear polarization and circular polarization. The U-shaped patch antenna is to increase the bandwidth and also to reduce the antenna size. The antenna operating frequency range is 2.5 GHz and it can be used in RF energy harvester. The main aim of this study is to investigate, design and validate U-shape microstrip patch antenna. The VSWR, radiation pattern, return loss and bandwidth of the proposed antenna are explained and simulated using Ansoft HFSS Software package.

Key words: Microstrip antenna, U-shape antenna, RF energy harvesting, VSWR, efficient design, package

INTRODUCTION

In current years, the interest for broad-band antennas has increased for use in high-frequency and high-speed data communication. For consumer applications, printed antennas are cost-effective and easily covered up inside packages, making them well suited. Unfortunately, a microstrip patch antenna has a very narrow frequency bandwidth that blocks its utilization in typical communication systems. Though, if the frequency bandwidth could be extended a wide band microstrip antenna would demonstrate very useful in commercial applications such as 2.5, 3 and 4 G wireless systems, Wireless Local Area Networks (WLAN). The method of converting the source of raw energy into electrical energy is called as energy harvesting. Energy harvesting is the process of capturing small amounts of energy from one or more of these naturally-occurring energy sources.

U-slot was likewise applied on ultra wideband antennas for minimizing impedance. Be that as it may in microstrip patch antennas, U-slot was mostly developed for bandwidth improvement. The U-slot technique can likewise be utilized to design patch antennas with double and multi-band characteristics. U-slots in the patch, notches are presented inside the matching band, resulting in multi-band operation.

Researchers have devised a few strategies to increase the bandwidth of microstrip antennas as well as the basic methods of rising patch height and lessening substrate permittivity. These incorporate utilizing a multilayer structure comprising of a few parasitic radiating elements with somewhat extraordinary sizes over the determined element or a planar patch antenna surrounded by firmly spaced parasitic patches. The stacked patch antenna improves the thickness of the antenna while the coplanar geometry expands the parallel size of the antenna.

A single-layer single-patch antenna through addition of high loss material or resistors additionally increases bandwidth but compromises the antenna's efficiency and gains. The bandwidths of single patch antennas can also be improved by implementing interior structures, for example, shorting pins or slots. In this study, the U-shape microstrip patch antenna design has been proposed based on resonant frequency 2.5 GHz for the application of RF energy harvesting.

Literature review: The effect of arm angle on the whole impedance of U-slot patch antenna has been described (Khan and Chatterjee, 2016) with vertical and L-probe feed. To increase the arm angle with vertical probe causes inductive move however in L-probe, capacitance because of electromagnetic coupling of horizontal part of the probe adjust this inductive shift and enhances impedance

Corresponding Author: S. Parasuraman, St. Peter's University, 600054 Chennai, Tamil Nadu, India

matching. The U-slot microstrip antenna has separated into two parts, one is to improve the finite ground plane size and the other is to increase the bandwidth of the antenna (Mahmoud, 2008).

The dual-band CPW-fed slot antenna with a C-shaped grounded strip is proposed by Chen *et al*. (2011). The lower band is accomplished by the slots loaded in two different corners and the C-shape grounded strip can suggest a current path for the upper band. Antennas are considered as the heart of RF energy harvesting system. In a microstrip patch antenna, the main disadvantage is its narrow bandwidth which can be countered through various geometric shapes (Sangaran *et al*., 2006).

A double band dual-sense CPW-fed slot antenna with two spiral slots loaded has been explained by Chen and Yung (2009). The two loaded spiral slots in the ground plane can result in various senses of circular polarization. By utilizing the T-shape strip, the dual-band operation is achieved. The dual feed U-slot antenna is analyzed by Ye *et al*. (2015). The analysis formulations set and an iterative design process with logical accuracy are provided to optimize the performance of the developed antenna in practicing engineering. The principle design procedures through examination of the structure's multiple resonant frequencies as well as the impedance and radiation properties of various antenna geometries (Weigand *et al*., 2003). The U-slot folded shorted path antenna (Kundu *et al*., 2014) is used as RF energy harvesting antenna for receiving the signals for capturing signal of GSM-900 band.

MATERIALS AND METHODS

Antenna design: Micro strip antenna is the easiest geometry for designing and implementation. The design of U-shape micro strip patch antenna is seen in Fig. 1. A simple U-slot micro strip patch antenna is designed to operate at 2.5 GHz. FR4_epoxy is used as the insulator as it is light in weight and also have good mechanical strength. The air material is used as radiation boundary. The height is 45 mm and the thickness is 1 mm and the length L1 = 15 mm, L2 = 15 mm, L3 = 15 mm, L4 = 29 mm, L5 = 25 mm, L6 = 36 mm, L7 = 17 mm, L8 = 3.8 mm, L9 = 0.3 mm, L10 = 0.3 mm.

The radiation boundary of the U-shape microstrip antenna design is shown in Fig. 2 and the perfect electric conductor of U-shape microstrip antenna design is shown in Fig. 3.

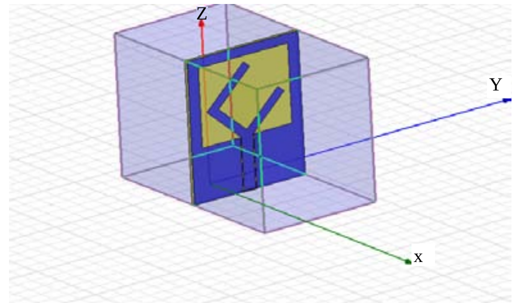

Fig. 1: U-shape microstrip patch antenna

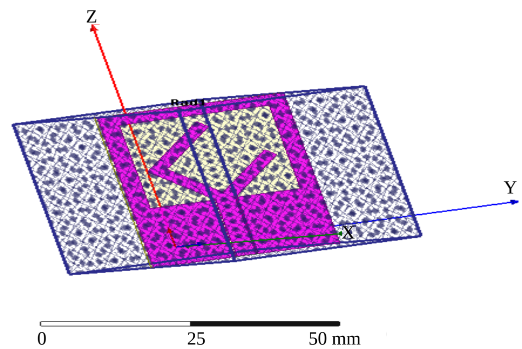

Fig. 2: Radiation boundary

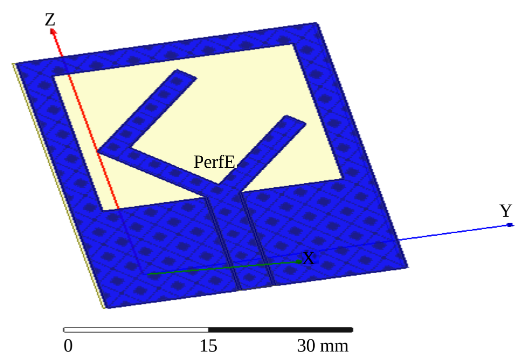

Fig. 3: Perfect electric conductor material

RESULTS AND DISCUSSION

The high performance of Ansoft HFSS full wave Electromagnetic (EM) field simulator. It integrates simulator, modeling and automation in an easy-to-learn location where solution of 3D EM problem is fastly and exactly obtained. Ansoft HFSS can be used to calculate parameters such as return loss, gain, radiation pattern and VSWR, etc.

The measured parameters of U-shape microstrip patch antenna is shown in Fig. 4-7. The frequency at

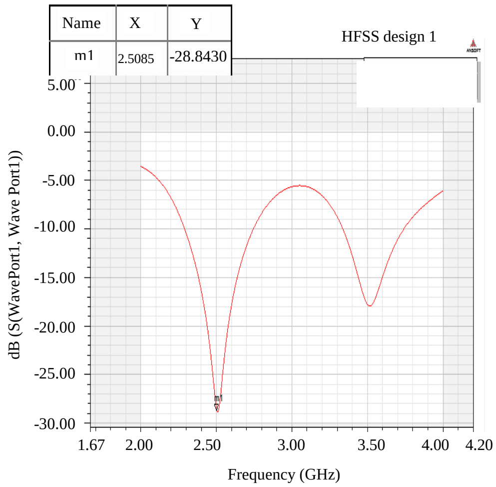

Fig. 4: Return loss; XY Plot 1; Curve Info dB (S(Wave Port 1, Wave Port 1)) U-strip: Sweep 1

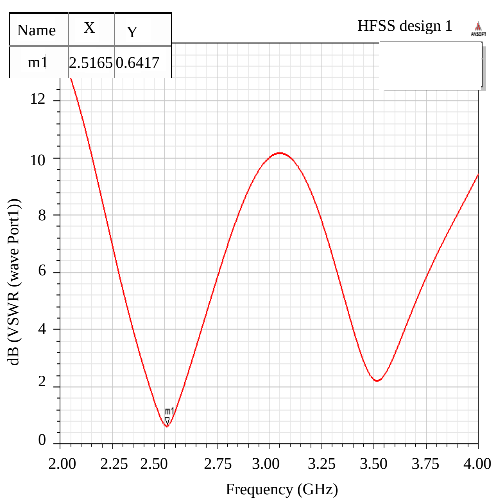

Fig. 5: VSWR; XY Plot 6; Curve Info dB(VSWR(Wave Port 1) U-strip: Sweep 1

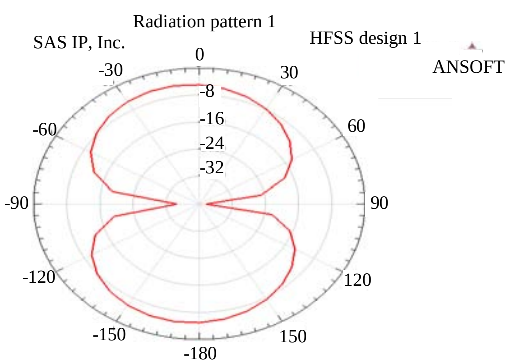

Fig. 6: Radiation pattern; Max(dB(GainPhi)) U-strip: Last adpative frequency = 2.5 GHz

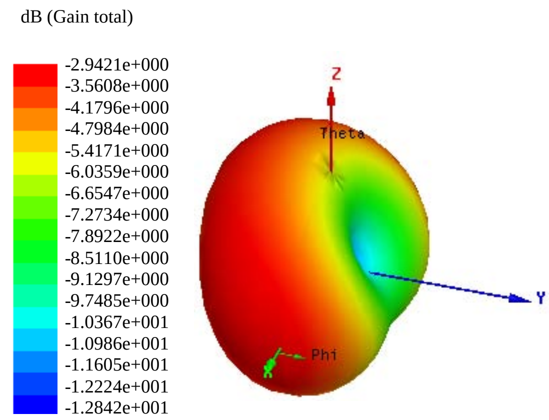

Fig. 7: The 3D polar plot (gain)

Table 1: Antenna parameters

Quantities	Values	Units
Max U	0.04038	W/sr
Peak directivity	0.56940	-
Peak gain	0.50792	-
Peak realized gain	0.50745	-
Radiated power	0.89119	W
Accepted power	0.99907	W
Incident power	0.99999	W
Radiation efficiency	0.89202	-

2.5 GHz, the return loss is -28.8 dB and VSWR is 0.64 (1 dB), the radiation pattern is -6 dB and the gain is -2.94 dB is shown in Fig. 4-7.

Table 1 shows that, the antenna parametersof Max U is 0.04 W/sr, peak directivity is 0.56, peak gain is 0.507, peak realized gain is 0.5, radiated power is 0.8 W and radiation efficiency is 0.8 W.

CONCLUSION

The U-shape microstrip patch antenna design for RF energy harvester for low power consumption electrical and electronic devices has been proposed in this study. The obtained result of this antenna is peak gain of 0.507 dB, peak directivity is 0.569 dB and the peak realized gain is 0.507 dB. The value of VSWR for this antenna is 0.64 dB and the return loss is -28.8 dB at 2.5 GHz resonant frequency.

RECOMMENDATIONS

In future, these antenna parameters can be more enhanced by changing the dimension of antenna and also, it could be applied in various types of wireless sensor networks application.

REFERENCES

Chen, C. and E. Yung, 2009. Dual-band dual-sense circularly-polarized cpw-fed slot antenna with two spiral slots loaded. IEEE Trans. Antennas Propag., 57: 1829-1833.

Chen, Y.Y., Y.C. Jiao, G. Zhao, F. Zhang and Z.L. Liao *et al*., 2011. Dual-band dual-sense circularly polarized slot antenna with a C-shaped grounded strip. IEEE. Antennas Wirel. Propag. Lett., 10: 915-918.

Khan, M. and D. Chatterjee, 2016. Effect of feeding techniques on U-slot loaded microstrip patch. Proceedings of the 2016 IEEE International Symposium on Antennas and Propagation (APSURSI'16), June 26-July 1, 2016, IEEE, Fajardo, Puerto Rico, ISBN:978-1-5090-2887-0, pp: 195-196.

Kundu, D., A.W. Reza and H. Ramiah, 2014. Design of an U-slot folded shorted patch antenna for RF energy harvesting. Proceedings of the 2nd International Conference on Innovations in Engineering and Technology (ICCET'14), September 19-20, 2014, Institute of International Education, Penang, Malaysia, Institute of International Education, Penang, Malaysia,-57.

Mahmoud, M., 2008. Improving the bandwidth of U-slot microstrip antenna using a new technique (trough-slot patch). Proceedings of the 2008 IEEE Conference on Region 5, April 17-20, 2008, IEEE, Kansas City, Missouri, ISBN:978-1-4244-2076-6, pp: 1-6.

Sangaran, M., A. Ramasamy, N.M. Din and K.K.A. Devi, 2006. Comparison on microstrip patch antenna modules and rectifier modules for RF energy harvesting. ARPN. J. Eng. Appl. Sci., 11: 6228-6233.

Weigand, S., G.H. Huff, K.H. Pan and J.T. Bernhard, 2003. Analysis and design of broad-band single-layer rectangular U-slot microstrip patch antennas. IEEE. Trans. Antennas Propag., 51: 457-468.

Ye, X., M. He, Y. Hao, Y. Wang and G. Wang, 2015. Analysis and design of dual-feed circularly polarized U-slot microstrip antennas. Proceedings of the 2015 IEEE International Conference on Communication Problem-Solving (ICCP'15), October 16-18, 2015, IEEE, Guilin, China, ISBN:978-1-4673-6543-7, pp: 300-302.