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PARAMETRIC ANALYSIS OF A MINIATURIZED INVERTED Π SHAPED ANTENNA FOR WIRELESS SENSOR NETWORK APPLICATIONS

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Abstract

A compact and simple design of a CPW-fed planar antenna for wireless sensor network antenna application with a better size reduction is presented. The proposed antenna consists of an inverted π shaped metal patch on a printed circuit board fed by a 50-Ω coplanar waveguide (CPW). The parametric analysis of length and width are made. The designed antenna's physical dimensions are 32 mm (length) x 26 mm (width) x 1.6 mm (height). The antenna structure has been modeled and fabricated and its performance has been evaluated using a method of moment based electromagnetic simulator, IE3D .The return loss of -22.5 dB and VSWR of 1.34 dB are noted. The radiation pattern of the antenna proves that it radiates in all direction. The antenna is fabricated and tested and the measured results go in good agreement with simulated one.

Keywords:

CPW Antenna, Impedance Matching, Return Loss, Radiation Pattern, Wireless Sensor Network

1. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions [1]. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes. The wireless protocol used depends on the application requirements [2]. As information needs to be transmitted in real time, communication between different regions should be easy to set up and the need of transmission lines should be eliminated. Consequently, feasible miniature wireless sensors are considered to be promising candidates for communication devices [3]. As WSN has tremendous applications, their demand is increasing now-a-days. There are also many constraints in designing a wireless sensor network such as power management, cost, size of sensing nodes, scalability, security etc. Size of the antenna plays a vital role in sensing node design[4]. Thus antenna designed for WSN should have a compact size, low profile, low power, low cost, easy fabrication, and sufficient transmission range. Planar antennas have attracted much interest due to their low profile, light weight, conformability and easy manufacturing though they also have disadvantages such as narrow bandwidth and low power capacity [5]. There are various feeding mechanisms. Coplanar waveguide (CPW) feeding is supposed to be better candidates because of their simple configuration, manufacturing advantages, repeatability and low cost [6].

The coplanar waveguide was proposed by C.P. Wen in 1969. A coplanar waveguide structure consists of a median metallic strip deposited on the surface of a dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface. This transmission line is uniplanar in construction, which implies that all of the conductors are on the same side of the substrate [6]. They have many features such as low radiation loss, less dispersion, easy integrated circuits and simple configuration. The CPW fed antennas have recently become more and more attractive because of its attractive features such as wider bandwidth and better impedance match [7]. This paper will focus on design and analysis of inverted π-shaped patch antenna with CPW feed which operates in 2.4GHz .The antenna may have miniaturized size compared to the wavelength at 2.4GHz.

2. ANTENNA DESIGN

The geometry of the proposed antenna has been shown in Fig1. The antenna consists of a rectangular finite substrate with inverted-π shaped patch. The CPW feeding method is used. The total length L of the antenna is 32 mm and the width is 26mm. The FR4 substrate of 1.6 mm thickness is used.

Table.1. FR-4 Substrate Properties

Permittivity(ε)	4.4
Permeability(μ)	1
Loss tangent	0.02
Dielectric thickness	1.6mm

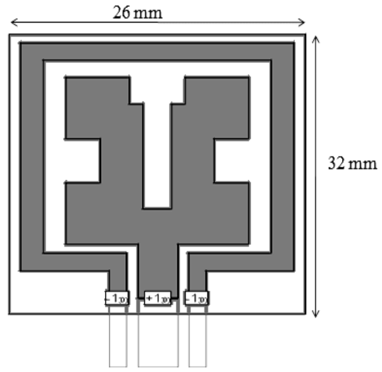

Fig.1. Geometry

For the proposed antenna design, IE3D simulation Software is used, which is full wave electromagnetic Simulation software for the microwave and millimeter wave integrated circuits. The primary formulation of the IE3D software is an integral equation obtained through the use of Green's function [12]. The simulation using IE3D, takes into account, the effect of co-axial SMA connector, by which the antenna was fed.

2.1 PARAMETRIC ANALYSIS

As the dimensions of the slots are varied, the response of the antenna also changes. It can be analyzed with the return loss graph.

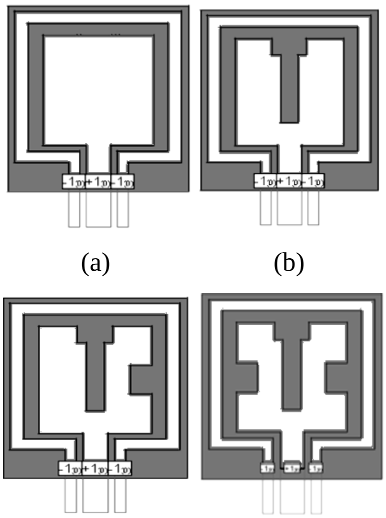

Fig.2. Geometry Analysis

When a rectangular patch is used as in Fig.2(a), the antenna radiates at two frequencies of 2.4 and 3.8 GHz. In order to make the antenna resonate at a single frequency, a slot is introduced in the rectangular patch.

Initially a slot is introduced along the width of the patch as in Fig.2(b). When the response is analyzed, the return loss is better at 2.4 GHz. To increase the return loss, another slot is introduced along the length of the patch in the left side as in Fig.2(c). The return loss is increased to -23dB at 2.4GHz, but dual band response is obtained

To make the antenna as a single band antenna, another slot is introduced in the right side of the patch as in Fig.2(d). Finally, the antenna resonates at 2.4 GHz with a return loss of -22.5 dB and VSWR of 1.34.

3. RESULTS AND DISCUSSION

The design of this work gives the following simulation results; the return loss is -22.5dB at 2.4 GHz and the VSWR obtained is 1.34dB.The gain of the antenna obtained is 3.22dBi and the directivity is 3.94dBi. The return loss is a measure of how well the antenna is perfectly matched. The return loss graph of the simulated design is shown in Fig.4.

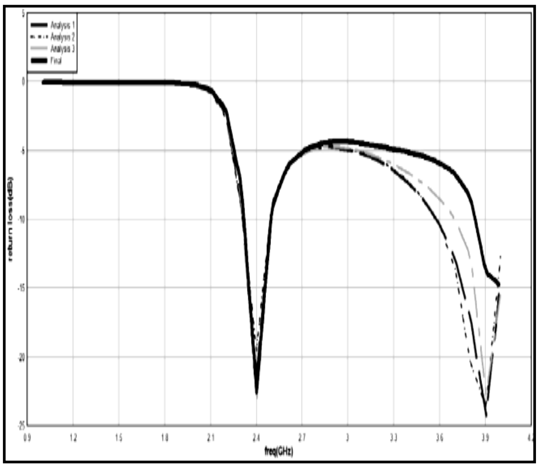

Fig.3. Return loss analysis

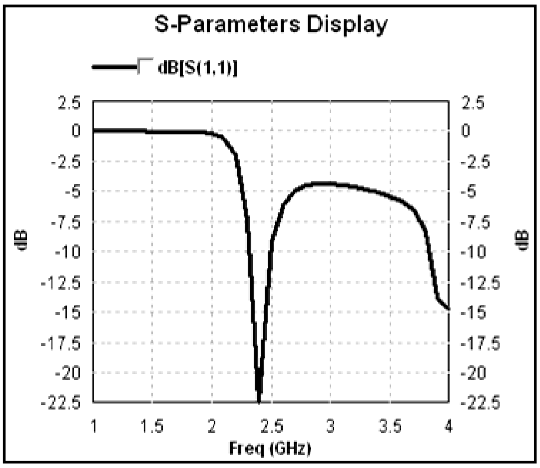

Fig.4. Return loss

The VSWR value should be very small and between 1 and 2. The simulated design has VSWR of 1.34 dB at 2.4 GHz as in Fig.5.

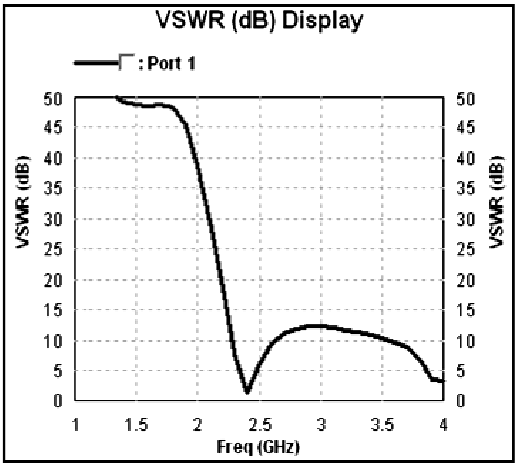

Fig.5. VSWR

The radiation pattern is related to the directivity and also the gain of the antenna. For the proposed design an omni-directional pattern is obtained. The radiation pattern in the 3D view of the simulated antenna is shown in Fig.6.

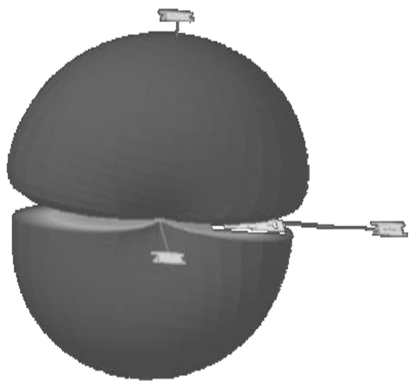

Fig.6. 3D Radiation Pattern

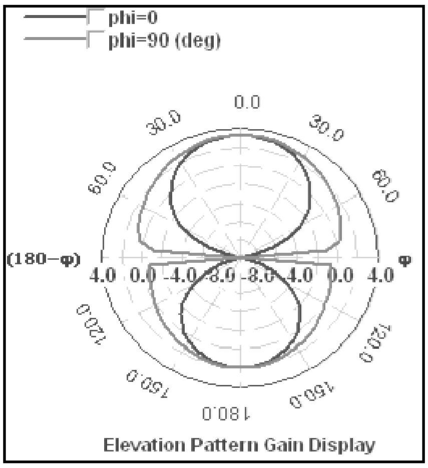

Fig.7. 2D Radiation Pattern

The 2D pattern of the simulated antenna is obtained as in Fig.7. The current distribution of the proposed antenna is shown in Fig.8. The proposed antenna is fabricated (Fig.9) and analyzed using the network analyzer. The results are compared with that of the simulated results.

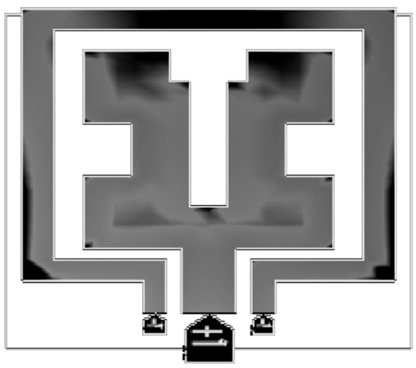

Fig.8. 3D Current Distribution Display

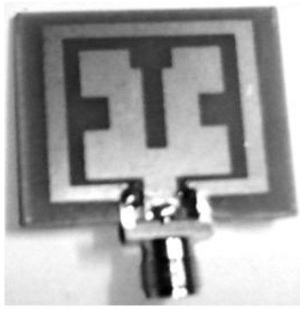

Fig.9. Fabricated antenna

The measured results of the fabricated antenna using the network analyser are depicted below.

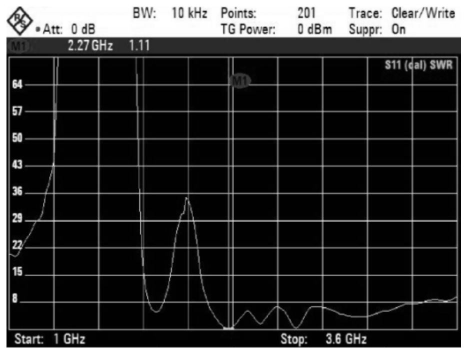

Fig.10. Measured VSWR

The simulated and the measured results of the proposed antenna are compared. The deviations in the result are due to the inaccuracy in fabrication and also SMA losses.

4. CONCLUSION

The CPW feed patch antenna has been designed for WSN applications. The parametric analysis helps to design an ideal antenna for wireless sensor network. A size reduction of 21% can be achieved with respect to physical length of the antenna. Whereas the expected electrical length of the antenna is 36mm for 2.4 GHz. From the analysis, it can be concluded that the antenna has good performance with a return loss of -23dB and VSWR of 1.34.The 2D and 3D radiation prove that the antenna has omni-directional radiation pattern. The simulated and the measured results are found to be in good agreement with each other.

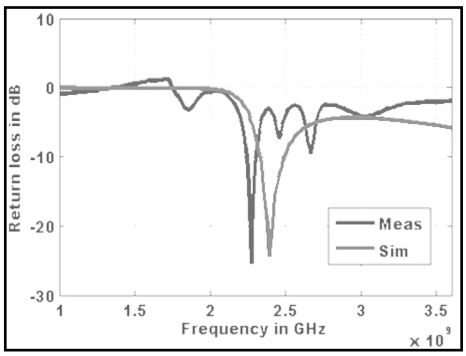

Fig.11. Comparison of Return loss

REFERENCES

[1] Y.S. Jeong, Y. J. Chung and J. H. Park. "Visualisation of efficiency coverage and energy consumption of sensors in wireless sensor networks using heat map", *IET Communications*, Vol. 5, No. 8, pp. 1129-1137, 2011.

[2] G. Elangovan and J. R. Perinbam, "Wideband E-Shaped Microstrip Antenna Wireless Sensor Networks", *American Journal of Applied* Sciences, Vol. 9, No. 1, pp. 89-92, 2012.

[3] Yingshu Li, My T. Thai, and Weili Wu (Eds.), "*Wireless sensor networks and applications*", Springer, 2008.

[4] Shaowen Hu, Yiqiang Wu, Ye Zhang and Huilin Zhou, "Design of a CPW-Fed Ultra Wide Band Antenna", *Open Journal of Antennas and Propagation*, Vol. 1, No. 2, pp. 18-22, 2013.

[5] Huang, Jung-Tang, Jia-Hung Shiao and Jain-Ming Wu, "A miniaturized Hilbert inverted-F antenna for wireless sensor network applications", *IEEE Transactions on Antennas and Propagation*, Vol. 58, No. 9, pp. 3100-3103, 2010.

[6] Akash Verma, Abhishek Yaduvanshi and Leena Varshney, "Design and Analysis of UWB Microstrip Patch Antenna", *International Journal of Advanced Computer Research*, Vol. 2, No. 4, pp. 340-344, 2012.

[7] Yongjin Kim and D-H. Kwon, "CPW-fed planar ultra wideband antenna having a frequency band notch function", *Electronics Letters*, Vol. 40, No. 7, pp. 403-405, 2004.

[8] Mandal, Tapan and Santanu Das, "A Coplanar Waveguide Fed Ultra Wideband Hexagonal Slot Antenna With Dual Band Rejection", *Progress in Electromagnetics Research C*, Vol. 39, pp. 209-224, 2013.

[9] Yonglun Luo, Liang Xu, Zhengyu Xin and Shuang He, "A Compact Cpw-Fed Uwb Antenna With Gsm, Gps, Bluetooth And Dual Notch Bands Applications", *Progress In Electromagnetics Research C*, Vol. 35, pp. 205-219, 2013.

[10] Manoj K. Shrivastava, A. K. Gautam and Binod K. Kanaujia, "An M-shaped monopole-like slot UWB antenna", *Microwave and Optical Technology Letters*, Vol. 56, No. 1, pp. 127-131, 2014.

[11] Yong Liu, et al., "Some Recent Developments of Microstrip Antenna", *International Journal of Antennas and Propagation*, Vol. 2012, 2012.

[12] Keith R. Carver and James Mink, "Microstrip antenna technology", *IEEE Transactions on Antennas and Propagation*, Vol. 29, No. 1, pp. 2-24, 2003.

[13] M. Ali, "Miniaturized packaged (embedded) antennas for portable wireless devices" in *Encyclopedia of RF and Microwave Engineering*, pp. 3068–3082, 2005.

[14] Kamil Boratay Aliciaand Ekmel Ozbay, "Electrically small split ring resonator antennas", *Journal of applied physics*, Vol. 101, No. 8, 2007.

[15] Simone Genovesi, Sergio Saponara and Agostino Monorchio, "Parametric design of compact dual-frequency antennas for wireless sensor networks", *IEEE Transactions Antennas and Propagation*, Vol. 59, No. 7, pp. 2619-2627, 2011.

[16] Rajendra R. Patil, Vani R. M and P.V. Hunagund, "Antenna Miniaturization Techniques for Wireless Applications", *International journal of Electronics*, Vol. 3, No. 3, 197-201, 2012.

[17] A. Kordzadeh and F. Hojat Kashani, "A New Reduced Size Microstrip Patch Antenna With fractal Shaped Defects ", *Progress In Electromagnetics Research B*, Vol. 11,29-37, 2009.

[18] IE3D Simulator, Zeland Software Inc., Fremont, CA, 1997.

[19] Kai Chang, "*Microwave ring circuits and antennas*", New York: Wiley, 1996.

[20] James R James, Peter S Hall and Colin Wood, "*Microstrip antenna*", London: Peregrinus, 1981.

[21] Warren L. Stutzman and Gary A. Thiele, "*Antenna theory and design*", John Wiley & Sons, 2012.

[22] David M. Pozar, "*Microwave and RF design of wireless systems*", John Wiley & Sons, 2000.