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A Study of Planar Inverted F Antenna (PIFA) for Wireless Applications

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ABSTRACT: The use of wireless handheld devices and mobiles is increasing day by day and more functions and standards are integrated to a single platform that allows maximum connectivity. The planar inverted-F antenna as a low profile antenna is widely used in several application areas due to several advantages. This paper deals with a comprehensive survey of various planar inverted F Antenna. Research and experiments done on PIFA structures are discussed and categorized in the paper. The conventional PIFA has an inherent narrowband that is not desirable in most modern handheld devices. Various methods used to improve its bandwidth; efficiency and reducing the dimensions of the PIFA are also discussed. These results will be useful for guiding PIFA design in practical applications.

Keywords: Planar Inverted F Antenna, Low profile, Bandwidth, SAR value

I. INTRODUCTION

For wireless handheld devices and cellular mobile communication, the Micro strip Patch Antennas are preferably selected mainly because of their low profile characteristics, portable structure and low cost. But still they have the area to improve their bandwidth and to reduce their size, to make these more compact. Thus, Planar Inverted-F Antennas (PIFA) has come into interest. The Planar Inverted-F Antenna (PIFA) can be observed as evolved from two well known antennas, namely quarter-wavelength monopole and rectangular micro strip patch antenna. Now, PIFA is widely used in handheld and mobile applications due to its attractive features such as simple design, low-profile, lightweight, low-cost, conformal nature, relatively low specific absorption rate (SAR) and good performance [1, 2]. PIFA is also considered as one of the powerful candidates for multiple input multiple output (MIMO) systems [3].

In literature, wide range of applications use PIFA as their basic antenna element covering frequency band of GSM 850 (824 to 890 MHz), GSM 900 (890 to 960 MHz), DCS/GSM 1800 (1710 to 1880 MHz), PCS/GSM 1900 (1.850 to 1990 MHz), WiBro (2.300 to 2.4 GHz), Bluetooth (2.4 to 2.48 GHz), DVB-H (UHF: 470 to 862 MHz; L: 1452 to 1492 MHz),802.11 (2.4 to 2.485 GHz), WLAN (5.16 to 5.5 GHz), UMTS and 4G LTE. The present research works are mainly focused in the following areas: (1) Mathematical formulation and analysis of characteristic parameters of PIFA antenna using experimental, analytical and numerical methods. (2) Technology improvement for Bandwidth enhancement, Multi band operations and reduction in size. (3) PIFA as an array element. (4) Electromagnetic interaction of PIFA with user's body.

The major limitation of the conventional PIFA is its inherent narrow bandwidth. It is important to enhance the bandwidth to fulfill the requirements imposed by the new handsets. This paper goes on briefly discussing about some important aspects of PIFA technology.

The remainder of this paper is organized as follows. Section II discusses the basic structure of PIFA and its basic design equations.

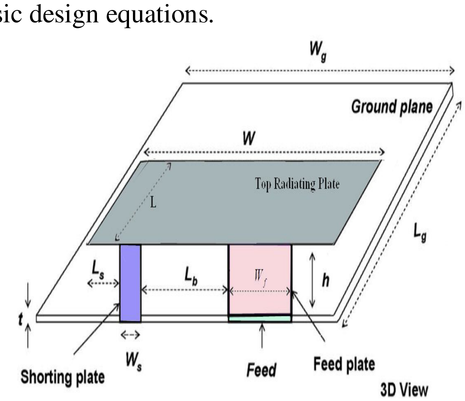

Fig.1. Typical Layout of PIFA.

The factors affecting bandwidth of PIFA and suitable ways to enhance the bandwidth are presented in Section III, which is followed in Section IV by a discussion of the SAR characteristics of PIFA. Section V discusses the use of PIFA as an array element. Finally, section VI presents our conclusions

II. PLANAR INVERTED F ANTENNA

The basic PIFA (a "grounded" patch antenna - $\lambda/4$ patch length instead of the conventional $\lambda/2$) consists of a ground plane, a top radiating plate, a feed wire feeding the resonating top plate, and a DC-shorting plate that is connecting the ground and the top plate at one end of the resonating patch. It is found that PIFA characteristics are affected by various parameters including the width, length, height and position of the top plate, dimensions of the ground plane, width, length, height and position of the top radiating plate, positions and widths of feed pin/plate and shorting pin /plate. From the available literature it is also found that the width of feed pin/plate plays an important role in widening the antenna bandwidth.

Typical layout of a PIFA is shown in Figure. 1. The antenna is fed through feeding pin which connects the ground plane to the top radiating plate through the dielectric substrate. The shorting plate and shorting pin allows good impedance matching attained with the radiating patch above ground plane of size less than $\lambda/4$. So, the PIFA structure is of compact size than typical $\lambda/2$ patch antennas. The resonant frequency of PIFA can be calculated by using a basic equation as given below [2]

$$f_0 = C/(Wp + Lp) \qquad \ldots(1)$$

Where f_0 is the resonant/operating frequency, C is the speed of light/radio wave and Wp and Lp are the width and length of the radiating plate of the PIFA. This equation says that the sum of the width and length of the top plate should be $\lambda/4$. This is a very basic approximation and does not cover all the significant parameters that affect the resonant frequency of the antenna. Some research works are made to incorporate some antenna parameters (other than length and width of radiating plate). In [4], new empirical equation for predicting the resonant frequency of PIFA was proposed, which will consider almost all significant parameters that affect the resonant frequency.

$$f_0=C/(3Wp+5.6Lp+3.7h-3W_f-3.7Ws-4.3Lb-2.5Ls \ldots(2)$$

Table 1 show the effects of various PIFA parameters on Resonant Frequency, Fractional Bandwidth and Radiation Pattern where Wp and Lp are the width and length of radiating plate, h is the height of the antenna, W_f is the width of the feed plate, Ws is the width of the shorting plate, L_b is the horizontal distance between shorting and feed plates, Ls is the distance between the shorting plate and the edge of top plate.

III. TECHNIQUES TO INCREASE THE BANDWIDTH FOR THE PIFA

The planar inverted-F antenna (PIFA) is modified form of wire inverted-F antenna. The wire is replaced with a plate in order to enhance the bandwidth. However, PIFA is still generally considered as narrow-band antenna and a significant amount of research has been made to broaden its bandwidth. The main relationships among various parameters having influence on bandwidth are follows,

$$\text{Bandwidth} = [(f_U-f_L)/f_0] \propto (1/Q) \qquad \ldots(3)$$

One of the most frequently used methods to widen the bandwidth is to increase the height of the shorting plane, which would increase the volume [8]. It is not a useful method in the case of handheld devices because antenna needs to be fit in the chassis. Size of the ground plane is also affected on bandwidth. By adjusting the size of the ground plane, the bandwidth of a PIFA can be varied. For example, reducing the ground plane can widen the bandwidth of the PIFA.

Another factor is position of the top plate on the ground plane. To obtain maximum bandwidth, the radiating plate should be placed near the edges of the ground plane [5]. Some of the other simple and practically implementable approaches to enhance the bandwidth are changing the widths of shorting and feed plates [6] and addition of parasitic element [7]. While increasing the width of the feed plate and shorting plate, the impedance of the antenna changes slowly around the resonant frequency. This increases the impedance bandwidth of the antenna. When parasitic elements are added, multiple resonances are created and hence the bandwidth increases. The effects of various PIFA parameters on resonant frequency, fractional bandwidth and radiation pattern is shown in the Table1.

IV. SAR CHARACTERISTICS OF PIFA

Interaction of mobile/Handheld device antennas with human body is a major concern in cellular communications. The user's body (mainly head and hand), influences on the gain, voltage standing wave ratio (VSWR) and radiation patterns of the antenna. Furthermore, the thermal effect created while tissues are exposed to unlimited electromagnetic energy, can be a serious health hazard. So governments and other standard organizations have set exposure limit in terms of the specific absorption rate (SAR).

In the literature there are many studies about human body interaction of PIFA. In numerical simulations of human head interaction with PIFA it is observed that input impedance, VSWR and radiation patterns are slightly changed. When comparing the SAR value of PIFA with several types of antennas commonly used in handheld devices like monopole, helical and patch, PIFA shows the lowest SAR values. In the presence of hand only, the radiation efficiency of helical antenna is greater than that of PIFA, while in the presence of hand and head, radiation efficiency of PIFA is greater [8]. The SAR in the user's head induced by a PIFA is about half of that induces by a helical antenna. High SAR value means more energy is absorbed by human body hence decreases radiation efficiency. So low value of SAR not only reduces the health hazards but also increases the antenna efficiency and battery life of the device.

Table 1: The effects of various PIFA parameters on resonant frequency, fractional bandwidth and radiation pattern.

PIFA Parameters	Action	Resonant Frequency	Fractional Bandwidth	Radiation pattern
Dimensions of the ground Plane	Increase the length and width of ground plane	Decreases (not very sensitive)	Increases	Affects
Position of radiating plate on the ground Plane	Increase the distance from edges	Increases	Decreases	Significant effects
Dimensions of top plate	Increase the length/width of the top plate	Decreases	Increases slightly	Small effects only
Height of PIFA	Increase the height	Decreases	Increases	No significant effects
Distance from the edge of top plate to the shorting plate	Increase the distance L_s	Increases	Changes	Little effects
Position of feeding configuration under the top plate	Increase the distance L_b	Increases	Slight changes	Affects
Width of shorting plate	Increase the width of the shorting plate	Increases	Increases	No significant effects
Width of feed plate	Increase the width of feed plate	Increases	Increases	No significant effects

V. PIFA AS AN ARRAY ELEMENT

The use of multiple-element antenna arrays, implementing either spatial multiplexing schemes or diversity gain, has been extensively proposed for increasing the spectrum efficiency in wireless communication systems. In mobile communication systems such antenna arrays are already being used at the base stations. But, implementation and the performance of these schemes at mobile terminals are influenced by the electromagnetic coupling between the densely packed array elements and the spatial fading correlation PIFA is the widely used antenna in handheld devices and owing some advantages like low loss, susceptibility to both vertical and horizontal polarization which make suitable for indoor applications where multiple reflections can take place [9]. There for many research works are there about PIFA as an array element. Mutual coupling between the antennas is an important factor for evaluating the performance of antenna arrays and 'multiple-input multiple-output' (MIMO) systems. So, many researches are focusing to reduce mutual coupling between antenna elements. In Ref [8], set a slot on ground plane, which forces the circulation of current on the ground plane around the slit.

In this way, reduce the signal from one antenna port to the other. But, each small portion of PCB is needed for electronic components in small devices and so ground plane modification is not always practicable. Some of the other methods include introducing resonators in the ground plane and using decoupling and matching circuits. Recently a method was proposed in which capacitive load and capacitive feed technology is used to prevent current flow from one port to another and achieve very low mutual coupling with more than 24.5 dB of isolation over the operating bands [9].

VI. CONCLUSIONS

In this paper, we have attempted to do an intensive survey of the works done by various researchers on PIFA technology. In this review some of the important aspects of PIFA technology and PIFA design are considered. Various design considerations and applications are evolving in this area. We have observed that PIFA offers better scope in comparison with other low profile antennas while considering the SAR values, as an array element and for use in handheld devices. More research works and studies are needed to explore the full potential of PIFA and we expect it to have a good future in the quickly developing field of wireless technology.

REFERENCES

[1] Hirasawa, Kazuhiro, and Misao Haneishi, eds. *Analysis, design, and measurement of small and low-profile antennas*., Artech House on Demand, 1992.

[2] P. S. Hall, E. Lee and C. T. P. Song, "Planar Inverted-F Antennas, Chapter 7," In: by R. Waterhouse, Ed., *Printed Antennas for Wireless Communications*, John Wiley & Sons, Hoboken, 2007.

[3] Y. Gao, C. C. Chiau, X. Chen and C. G. Parini, "A Compact Dual-Element PIFA Array for MIMO Terminals," Loughborough Antennas & Propagation Conference, Loughborough, 4-5 April 2005.

[4] Chattha, Hassan Tariq, et al. "An empirical equation for predicting the resonant frequency of planar inverted-F antennas." *Antennas and Wireless Propagation Letters, IEEE* 8 (2009): 856-860.

[5] Chattha, Hassan Tariq, et al. "A comprehensive parametric study of planar inverted-F antenna." (2012).

[6] Chattha, Hassan Tariq, Yi Huang, and Yang Lu. "PIFA bandwidth enhancement by changing the widths of feed and shorting plates" *Antennas and Wireless Propagation Letters, IEEE* 8 (2009): 637-640.

[7] Chattha, H. T., et al. "Further bandwidth enhancement of PIFA by adding a parasitic element."*Antennas & Propagation Conference, 2009. LAPC 2009. Loughborough.* IEEE, 2009.

[8] Faruque, MR Iqbal, Mohammad Tariqul Islam, and Norbahiah Misran. "SAR analysis in human head tissues for different types of antennas." *World Applied Sciences Journal* 11.9 (2010): 1089-1096.

[9 Ray, Jhimlee Adhikari and SR Bhadra Chaudhuri, "A review of PIFA technology." *Antenna Week (IAW), 2011 Indian*. IEEE, 2011.

[10] Karaboikis, M., et al. "Compact dual-printed inverted-F antenna diversity systems for portable wireless devices." *Antennas and Wireless PropagationLetters, IEEE* 3.1 (2004): 9-14.

[11] LOU, Si-yan, Xiao-lin LI, and Zu-fan ZHANG. "High isolation dual-element modified PIFA array for MIMO application." *The Journal of China Universities of Posts and Telecommunications* 19.3 (2012): 1-6.