ISSN: 2321-8169
230 - 233

Simulation of Planar Inverted F Antenna for On-Body and free space Communication

Navdeep Kaur[1]
[1]Assistant Professor, Department of ECE
GNDU Regional Campus, Sathiala
Amritsar, India
navdhillon109@gmail.com

Pallavi Sharma[2]
[2] Assistant Professor, Department of ECE
Lyallpur Khalsa College of Engineering
Jalandhar, India
Pallvisharma58@yahoo.com

Abstract- The expansion of recent wireless communications devices has put significant Compression on the antenna performance, as the size of the device has decreased in parallel to the increase in the number of communications systems supported by a single terminal. The Body Area Network (BAN) helps constant monitoring of Human health with updates of medical records through Internet. In this paper, we propose an on-body and free space performance of Planar Inverted F antenna which operates in Industrial scientific and Medical (ISM) frequency band at 2.45 GHz. The planar inverted –F antenna is popular for portable wireless devices because of its low profile, small size, and built-in structure This antenna is designed to achieve better Specific absorption rate. Other field parameters like Gain, Directivity, Return loss and Radiation have been evaluated on the body and on free space antenna with FEM based software HFSS ver. 13.0.

Keywords: Body area network (BAN), On-body Communications, PIFA, Specific Absorption Rate (SAR), Muscle tissue

.*****

I. INTRODUCTION

Based on the positions of transmitter and receiver, BCWCs are having three types: In-body, On-body and Off-body communications [1]. In On-body communications, both the transmitter and the receiver are placed on single body [2]. Thus this communication proposes a PIFA operating at 2.45GHz for on-body communication which is easily mountable. This technology helps compensate health problem by consultating doctors and patient face to face and thus shortening hospital stays [3]. Due to the compact size, low manufacturing cost and appropriateness for multiband operation different configurations of PIFAs have attracted much care. The shielding effect of the ground plane is the advantage of PIFA. It results in reduced backward radiation and lower SAR values. Shorted planar antennas are self-resonant and no additional resonance or matching circuitries are needed, since the resonance tuning and impedance matching are built-in features of PIFAs. A basic PIFA setup is illustrated in Figure 2(a). The configuration consists of a shorted patch element on top of a ground plane with air substrate.

Some Authors also focused on some typical body postures that includes bending of body[4]. Body area network has numerous interconnected nodes close, on or in the body, which provide sensing, processing and communication abilities [5]. Many techniques were used by some authors to improve the bandwidth of antenna like aperture-coupled and Planar Inverted F Antenna (PIFA). Zhu et al have offered an antenna which use EBG surface for improving the return losses by preventing the back radiations [6-8]. One way to enhance the bandwidth is by using thick substrate layer between the patch and ground. Also the ground plane can also be used to increase the bandwidth by increasing or decreasing its size.

This paper is organized in four sections. In Section I, the introduction about WBAN and PIFA gives the brief explanation of on-body communication operating at frequency 2.45GHz and its applications in various fields. In section II Structure of the proposed antenna and phantom with dimensions and material used has been discussed. Section III presents the simulated results of on-body antenna as well as off-body antenna. Section IV concludes the results of proposed antenna.

II. ANTENNA DESIGN

A. Antenna Structure

In this paper, we propose the Planar Inverted F Antenna for On-body communication. Fig. 2(a) shows the geometry of the 2.45 GHz Planar Inverted F Antenna. The basic PIFA consists of a ground plane, a top plate element, a feed wire feeding the resonating top plate and a DC-shorting plate is connecting the ground and the top plate at one end of the resonating patch. The planar Inverted F Antenna with Phantom as well as without phantom is designed. A feed wire is used from the ground to the radiation top element. PIFA's can be designed with or without ground plane under the top plate element.

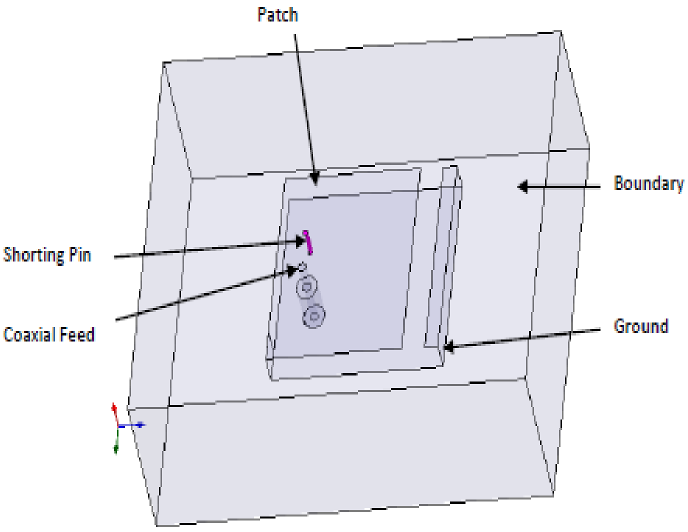

Fig.2 (a) Structure of proposed Antenna

It is 26.6 mm x 26.6 mm x 4.2 mm in size. A rectangular patch of dimension 21 mm x 25 mm is mounted on the feeding pin, shorting pin and shorting plate. The height between the rectangular patch and the ground plane is 3.8 mm; there is no dielectric material between the rectangular patch and the ground plane. The length of the ground plane is L = 34 mm. In this proposed antenna air is used as the substrate as it is free from the problems that can be due to substrate losses.

B. Phantom Structure

The proposed antenna was placed on a body-phantom with dimension of 100 mm × 90 mm. The phantom size is taken smaller because of the speed of the processor. The phantom consists of Muscle (ε_r= 53.57; σ = 1.81), Fat (ε_r= 5.28; σ = 0.10) and Skin (ε_r= 42.85; σ = 1.59)[4]. The thickness of Skin, Fat and Muscle are 2mm, 5mm and 9mm respectively. We considered a dielectric constant and conductivity. In the tissues any form of water-content is not considered in this proposed antenna as to reduce the complexity. These are the dimensions for tissue over which the antenna is mounted. It operates at the Industrial Scientific and Medical (ISM) frequency allocation of 2.4–2.48 GHz.

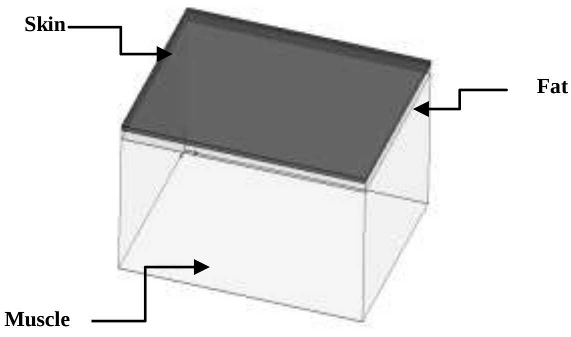

Fig.2 (b) Model of Phantom

III. SIMULATION RESULTS

In this Paper, several field parameters like SAR, Gain, Return loss and Radiation parameters are discussed for on-body and in free space. These Antennas are implemented by using software 'High Frequency Structure Simulation' (HFSS). The antenna is operated at resonant frequency of 2.45 GHz on a body tissue called phantom and without phantom by adjusting size of the patch. .

Fig. 3(a) and 3(b) shows the return loss graph of PIFA which is about -21.53 dB on the phantom and -23.44 dB in free space. Using a pin the radiating patch can effectively improve the bandwidth which is critical in cellular communications. It gives an impedance bandwidth of 150 MHz which is from 2.38 GHz to 2.53 GHz.

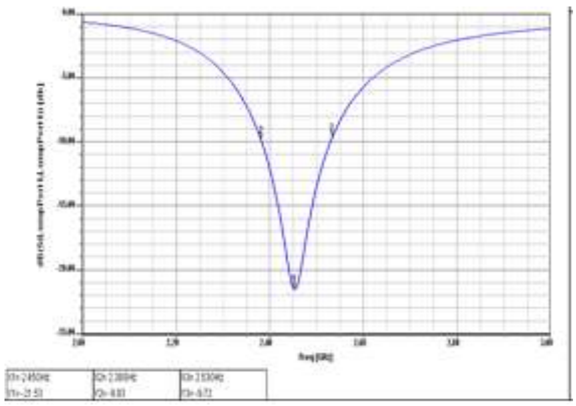

Fig.3(a). Return loss (S_{11}) of PIFA for on-body

ISSN: 2321-8169
230 - 233

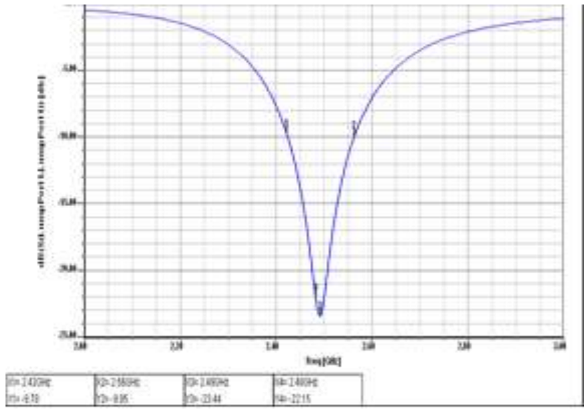

Fig.3(b). Return loss (S_{11}) of microstrip antenna for free space

The simulated gain of proposed antennas for Planar Inverted F Antenna is 6.147 dB with PIFA on body and 6.197 dB for free space in fig 3(c) and 3(d) respectively.

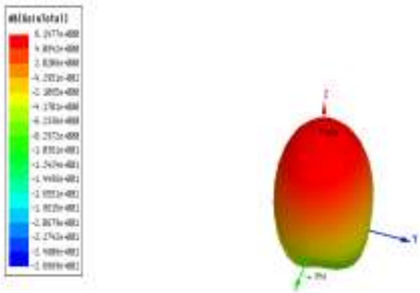

Fig.3(c) 3D polar plot of Gain of PIFA for on body

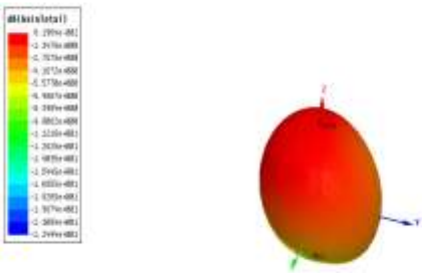

Fig.3(d) 3D polar plot of Gain of PIFA for space

VSWR is 1.47 at 2.45GHz for on body as shown in Fig.3(e) and 1.17 for free space as shown in fig. 3(f) which indicates good matching of impedance. The radiation characteristics of the antenna are controlled by the dimensions of the patch, feed location, substrate selection and ground plane separation.

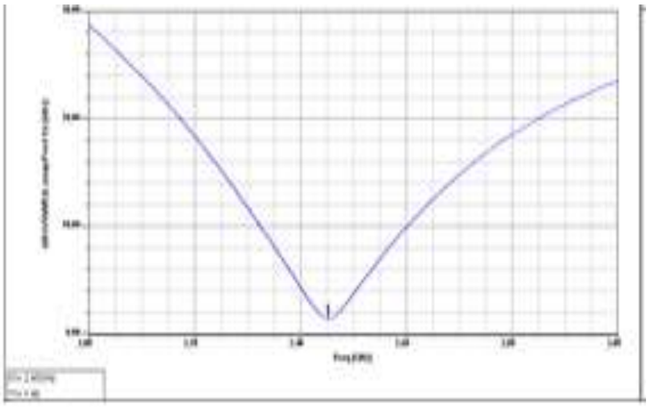

Fig.3(e). VSWR vs Frequency plot of PIFA On body antenna

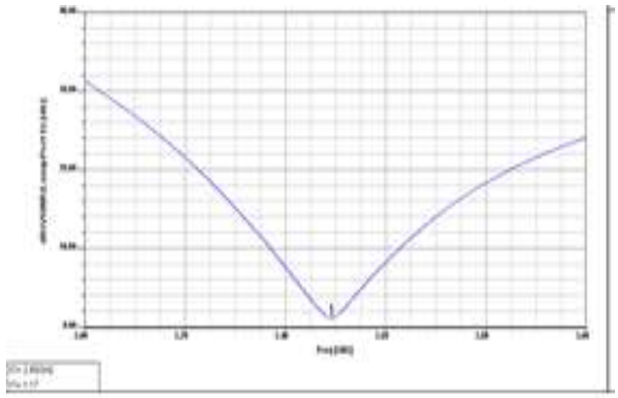

Fig.3(f). VSWR vs Frequency plot of PIFA for free Space

Human body behaves as a lossy dielectric and the EM radiation generated by mobiles are able to penetrate through semisolid substances like living tissues at communication frequency [13]. Specific Absorption Rate (SAR) is defined as the parameter which determines the absorption of electromagnetic energy by human fleshy tissues. The SAR is an critical factor for the antenna when it is operated on or inside the body. This power absorbed by user is measured by a parameter called Specific Absorption Rate, SAR, and is defined as below:

$$SAR = \frac{\sigma |E_t|^2}{\rho} = \frac{J^2}{\sigma\rho} \tag{1}$$

Where σ is the conductivity and ρ is the mass density, t is the total amplitude of electrical field in root mean square. An average integral is used locally over a mass block to transfer from point SAR to average SAR The Federal Communications Commission (FCC) of the United States that the normal limits

ISSN: 2321-8169
230 - 233

for the antenna designer are 2 W/kg (10 g of tissue) in Europe and 1.6 W/kg (1 g of tissue) in the USA. [14]. The SAR value of designed antenna is 1.56 W/Kg for Planar Inverted F Antenna.

IV. CONCLUSION

The performance parameters of the proposed Planar inverted F Antenna operating at ISM band i.e 2.45GHz is investigated in this paper. As a result we achieve almost same results on the body and in free space. It shows that the designed antennas have less effect on the body due to having less SAR value. We also achieve the required gain and bandwidth which is useful in ISM band. We adopted PIFA technique to achieve all the above parameters. In addition, the resonant frequency of the proposed antenna on the body and in Free space are almost same.

REFERENCES

[1] Rajni et.al " Design and simulation of Microstrip patch antenna for on-body communication using different feeding techniques" in international conf. UACEE, Dehradun,Augest 2013.

[2] K. L. Wong and C. I. Lin, "Characteristics of a 2.4-GHz compact shorted patch antenna in close proximity to a lossy medium," *Microw. Opt. Technol. Lett.*, vol. 45, no. 6, pp. 480–483, 2005..

[3] William G. Scanlon et. al, "Antennas for Over-Body-Surface Communication at 2.45 GHz," *IEEE Transaction Antennas propagation.,vol. 57, no. 4, Apr 2009.*

[4] Gareth A. Conway et. al, "Low-Profile Microstrip Patch Antenna for Over- Body Surface Communication at 2.45 GHz" *IEEE, 2007.*

[5] Mark A. Hanson et. al., "Body Area sensor network: Challenges and opportunities", IEEE 00018-9162, 2009.

[6] Chia-Hsien Lin, Kazuyuki Saito, Masaharu Takahashi, and Koichi Ito, "A Compact Planar Inverted-F Antenna for 2.45 GHz On-Body Communications", *IEEE Transaction Antennas propagation.,vol. 60, no. 5, sept 2012.*

[7] P. S. Hall et.al "Diversity Measurements for On-Body Communication Systems" *IEEE Transaction Antennas propagation.,* Vol. 6, Apr 2007

[8] S. Zhu and R. Langley, "Dual-bandwearable textile antenna on an EBG substrate," *IEEE Trans. Antennas Propag.*, vol. 57, no. 4, pp. 926–935, Apr. 2009.

[9] Timothy F. Kennedy et.al, "Body-Worn E-Textile Antennas: The Good,the Low-Mass, and the Conformal" *IEEE Transactions on Antennas And Propagation, Vol. 57, No. 4, April 2009.*

[10] Hendrik Rogier *et.al* "A Textile Antenna for Off-Body Communication Integrated Into Protective Clothing for Firefighters", *IEEE Transaction Antennas propagation.,vol. 57, no. 4, Apr 2009.*

[11] Shuo Chang et. al, "Compact Broad Dual-Band Antenna Using A Shorted Patch with A Thick Air Substrate for Wireless Body Area Network Application", *IEEE,2011.*

[12] "*Theory of a single Microstrip Square Patch''* internet source: http://surf.syr.edu/projects/SamirArrayAntenna/theory.doc.

[13] J. Soler et. al,, "Human body effects on implantable antennas for ism bands applications: models comparison and propagation losses study", *Progress In Electromagnetics Research, Vol. 110, 437,452, 201.*

[14] V.K.Lamba et al "Effect of Communication Frequency on Specific Absorption Rate Of Electromagnetic Radiations In Human Body" *International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-4, September 2012"*

[15] Soonyong Lee et. al., "Design of On-body Antenna for Wireless Body Area Network", *Feb.19-22, 2012 ICACT2012.*

[16] Nariman Firoozy, Mahmoud Shirazi, "Planar Inverted-F Antenna (PIFA) Design Dissection for Cellular Communication Application", *Journal of Electromagnetic Analysis and Applications*, 2011, 3, 406-411.