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# Design and Simulation of Microstrip Patch Antenna for On-Body Communication using Different Feeding Techniques

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***Abstract-* The Body Area Network (BAN) is an area which helps constant monitoring of Human health with real-time updates of medical records through Internet. In this paper, we propose an on-body performance of wearable Microstrip patch antenna which operates in Industrial scientific Medical (ISM) frequency band at 2.45 GHz. This antenna is designed to achieve better return loss gain and bandwidth. The antenna return loss is about -25.54 db with microstrip feed and -22.68 db with coaxial feed at 2.45 GHz. Another field parameters like Gain, Directivity, Radiation and Specific Absoption Rate (SAR) values have been evaluated on the body and on free space antenna with FEM based software HFSS ver. 10.0.**

***Index Terms*: Body-Centric Wireless Communications (BCWCs), On-body Communications, Microstrip patch antenna (MSA), coaxial feed, Specific Absoption Rate (SAR) Muscle tissue.**

## I. Introduction

Body Area networks (BANs) are becoming an important part of the mobile communications system. The increasing use of wireless networks and the miniaturization of devices have increased the development of Wireless Body Area Networks. The body area network field continuously monitors the health of the patient with real-time updates of medical records through Internet. In these networks various sensors are attached on the cloths weared by human being or directly attached on the body or even implanted into the body. Physiological sensors can be integrated into a body area network, which can be used for detection of medical conditions of human body at early stage. Body-Centric wireless Communications (BCWCs) draw an increasing amount of attention due to their applications in several areas, such as monitoring of health, military, security and home care devices. Wearable monitoring systems have the capability to monitor medical data in the home, diagnosis and control of the condition.

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Based on the positions of transmitter and receiver, BCWCs can be divided into three types: On-body, In-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 Microstrip Antenna operating at 2.45GHz for on-body communication which is easily mountable. This technology helps compensate for limited health care resources by reducing face-to-face consultations of doctors and patient and thus shortening hospital stays. An important aspect of body communications is the preservation of antenna performance, yet antennas must be small, unobtrusive to the user and, ideally conformable to the body surface [3].

Some Authors like P.S.Hall also focused on some typical body postures that includes bending of body[4]. Many papers have been published on BCWCs. Each body area network has multiple interconnected nodes near, on or in the body, which together provide sensing, processing and communication capabilities [15]. Large number of studies survey offered low profile solution. Various techniques were used by various authors to enhance the bandwidth of antenna like aperture-coupled and Planar Inverted F Antenna (PIFA). Zhu et al have presented an antenna using EBG surface to improve the return losses by improving back radiations [5-7]. One of the easiest ways to enhance the bandwidth is use of thick substrate layer. Also the size of the ground plane can also be used to increase the bandwidth.

This paper is organized in four sections. In Section I, the introduction about WBAN 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 with table includes all results. Section IV concludes the results of proposed antenna.

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# II. Antenna Geometry

## A. Antenna Structure

In this paper, we propose the Microstrip Patch Antenna for On-body communication. Fig. 2(a) shows the geometry of the 2.45 GHz Microstrip Patch Antenna. A rectangular patch with dimension 44.88mm ×36.4mm×2mm is mounted on a substrate 60 mm × 60 mm with $\varepsilon_r$ =2.2 and Dielectric loss tangent 0.0009 (RogersRT/ Duroid 5880(tm). The thickness of the substrate is 5 mm. In order to design an antenna with a sufficiently large bandwidth and sufficiently high radiation efficiency. The antenna consists of a ground plane of 50 mm × 60 mm. The antenna is excited by microstrip line feeding a patch at the center of the patch element having a dimension of 8mm ×3mm in size.

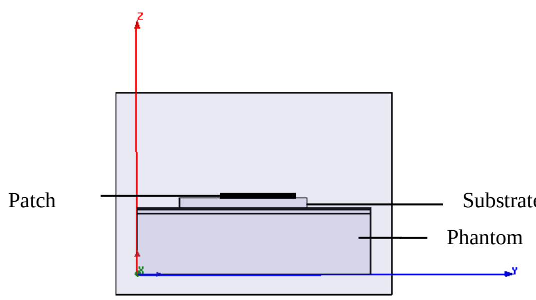


Fig.2 (a) Antenna with Microstrip feed

Fig. 2(b) shows the geometry of the 2.45 GHz antenna with coaxial feed. A rectangular patch with dimension 37.2mm × 22.3mm × 0.95um.Substrate 100mm × 90mm with $\varepsilon_r$ = 2.2 & Dielectric loss tangent 0.0009 (Rogers RT/ Duroid5880(tm). The thickness of the substrate is 3.2 mm.

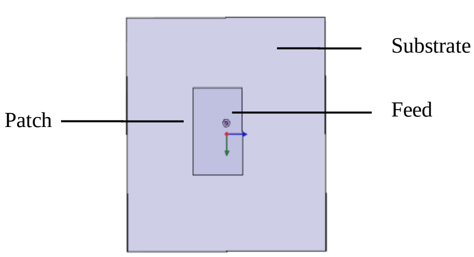


Fig.2(b) Antenna with coaxial feed

## B. Phantom Structure:

The proposed antenna was placed on a body-phantom with dimension of 90 mm × 80 mm. The phantom size is taken smaller because of the speed of the processor. The phantom consists of Skin ($\varepsilon_r$= 42.85; σ = 1.59), Fat ($\varepsilon_r$= 5.28; σ = 0.10) and Muscle ($\varepsilon_r$= 53.57; σ = 1.81) [4]. The thickness of Skin, Fat and Muscle are 1mm, 2mm and 10mm respectively. We considered a dielectric constant and conductivity. Any form of water-content in tissues is not considered in this simulation due to increase of 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.

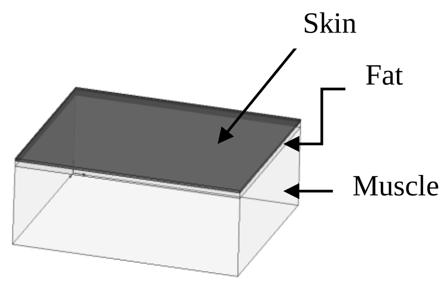


Fig.2 (b) Phantom Model

# III. Simulation Results

In this Paper, various field parameters like Gain, Return loss and Radiation parameters are discussed for on-body and in free space. These Antennas are implemented in Finite Element Method (FEM) based software 'High Frequency Structure Simulation' (HFSS). Using HFSS, the antennas is operated at resonant frequency of 2.45 GHz on a body tissue phantom and without phantom by appropriately adjusting size of the patch. Fig. 3(a) and 3(b) shows the return loss graph of Microstrip Patch Antenna which is about -25.54 dB on the phantom and -19.34 dB in free space. It gives an impedance bandwidth of 170 MHz which is from 2.34 GHz to 2.51 GHz.

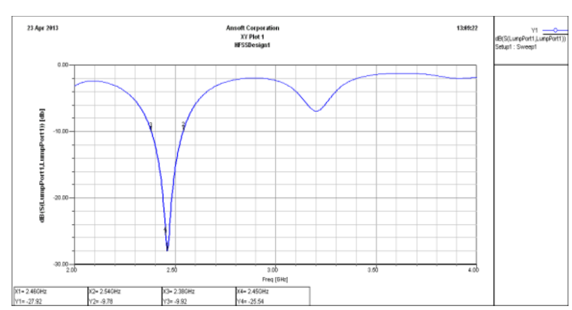

Fig.3(a). Return loss ($S_{11}$) of microstrip antenna for on-body

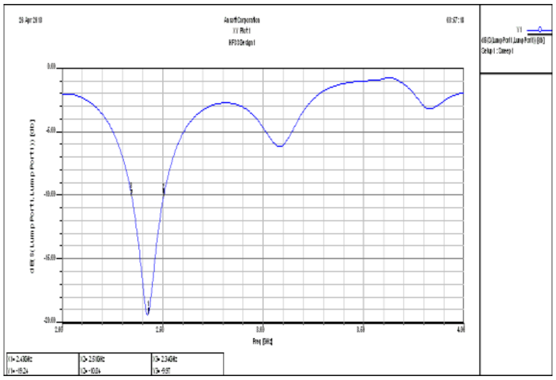

Fig.3(b). Return loss ($S_{11}$) of microstrip antenna for free space

The Return loss for coaxial feed for on-body is -24.50dB and in free space is -20.57dB as shown in fig 3(c) and fig 3(d) respectively.

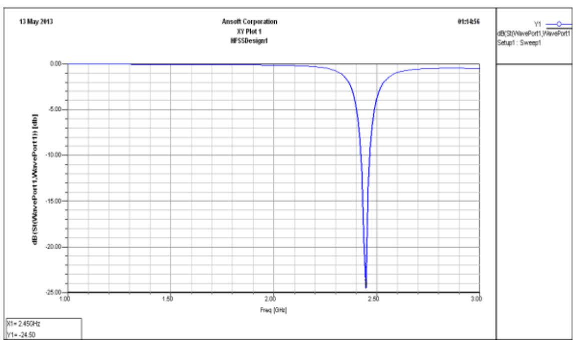

Fig.3(c). Return loss ($S_{11}$) of coaxial feed antenna for on-body

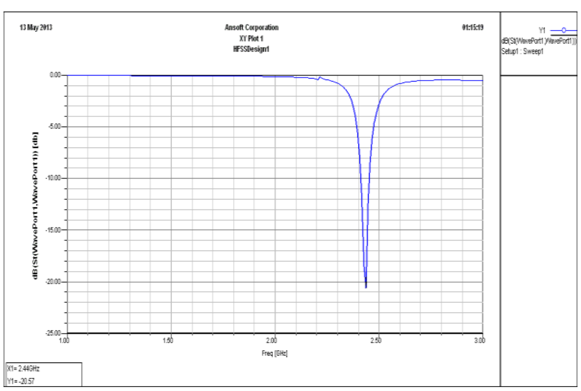

Fig.3(d). Return loss ($S_{11}$) of coaxial feed antenna for free space

The simulated gain of proposed antennas is 6.62 dB with microstrip feed and 7.09 dB with coaxial feed as shown in fig 3(e) and 3(f) respectively.

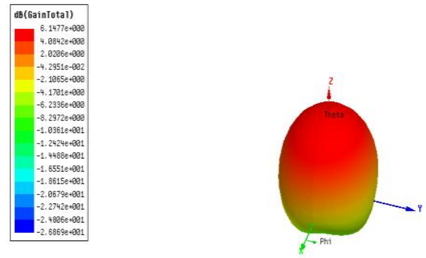

Fig.3(e) 3D polar plot of Gain of microstrip feed for on body

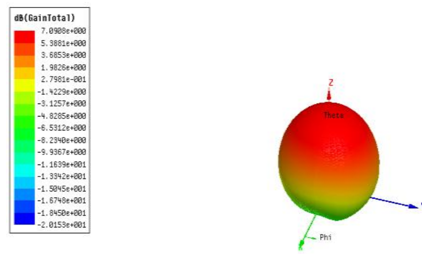

Fig.3(f) 3D polar plot of Gain of coaxial feed for on body

Directivity of proposed antennas are 6.65 dB for microstrip feed and 7.118dB for coaxial feed on the phantom.

Similarly VSWR is 1.11 for microstrip feed and also 1.11 with coaxial feed at 2.45GHz as shown in Fig.3 (g) and Fig.3 (h) 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.

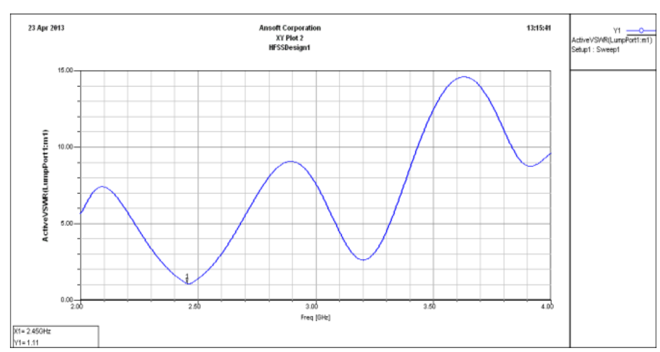

Fig.3(g). VSWR vs Frequency plot of microstrip feed antenna

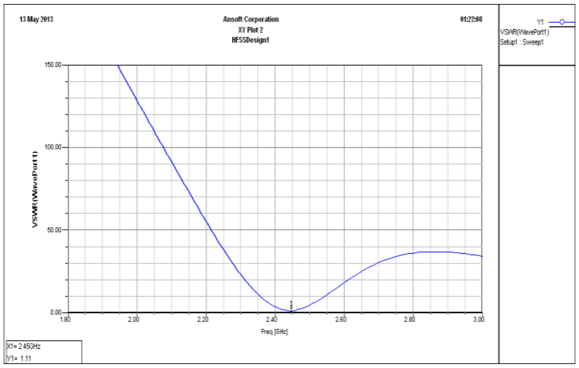


Fig.3(h). VSWR vs Frequency plot of coaxial feed antenna

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 [12]. Specific Absorption Rate (SAR) is the parameter used for determining the absorption of electromagnetic energy by human tissues. The SAR is an essential factor when the antenna is operated on or inside the human body. The Federal Communications Commission (FCC) of the United States requires that the SAR values should be below 1.6 watts per kilogram (W/kg) over a volume of 1 gram of tissue to evaluate SAR [14]. The SAR values of designed antennas are 1.4 W/Kg for microstrip and 1.92W/Kg for coaxial feed.

The results of performance parameters of proposed antenna using microstrip feed and coaxial feed for on body and off body are given in the table 1.

**TABLE 1. RESULTS OF PERFORMANCE PARAMETERS WITH DIFFERENT FEEDING TECHNIQUES FOR ON-BODY AND OFF BODY**

| | PARAMETERS | ON-BODY | FREE SPACE |
|---|---|---|---|
| Microstrip Feed | BANDWIDTH | 160MHz | 170MHz |
| | RETURN LOSS | -25.54dB | -19.24dB |
| | VSWR | 1.11 | 1.56 |
| | GAIN | 6.62dB | 6.56dB |
| | DIRECTIVITY | 6.65dB | 6.56dB |
| Coaxial Feed | BANDWIDTH | 50MHz | 50MHz |
| | RETURN LOSS | -24.50dB | -20.57dbB |
| | VSWR | 1.11 | 1.61 |
| | GAIN | 7.10dB | 6.93dB |
| | DIRECTIVITY | 7.12dB | 6.895dB |

# IV. Conclusion

The performance parameters of the proposed Microstrip Patch Antenna operating at 2.45GHz are investigated in this paper. As a result we achieve almost same results on the phantom and in free space. It shows that the designed antennas have less effect on the body due to having less SAR values. We also achieve the required bandwidth which is useful in ISM band. We adopted microstrip feedline and coaxial feed technique to achieve all the above parameters. In addition, the resonant frequencies of the proposed antenna on the phantom and in Free space are almost same.

## *References*

[1] P.Hall, "Antennas and propagation for body centric communications," *in Proc. IET Seminar Antennas and propagation Body-Centric Wireless Communications*, Apr. 2007.

[2] Gareth A. Conway and William G. Scanlon, "Antennas for Over-Body-Surface Communication at 2.45 GHz," *IEEE Transaction Antennas propagation.,vol. 57, no. 4, Apr 2009.*

[3] Gareth A. Conway, William G. Scanlon, "Low-Profile Microstrip Patch Antenna for Over- Body Surface Communication at 2.45 GHz" *IEEE, 2007.*

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

[5] 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.*

[6] 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.

[7] S. Zhu and R. J. Langley, "Dual band wearable antennas over EBG substrate," *IET Electron. Lett.*, vol. 43, no. 3, pp. 141–143, Feb. 2007.

[8] Carla Hertleer, Hendrik Rogier, *Senior Member, IEEE*, Luigi Vallozzi, and Lieva Van Langenhove, "A Textile Antenna for Off-Body Communication Integrated Into Protective Clothing for Firefighters", *IEEE Transaction Antennas propagation.,vol. 57, no. 4, Apr 2009.*

[9] Guangdong Liu, Degong Wang, Fulu Jin, Shuo Chang,"Compact Broad Dual-Band Antenna Using A Shorted Patch with A Thick Air Substrate for Wireless Body Area Network Application", *IEEE,2011.*

[10] 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.*

[11] J. Gemio, J. Parr¶on, and J. Soler, "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.*

[12] Amarjeet Kaur, Himani Malik, Asha Lather, V.K.Lamba, "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"*

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

[14] David L. Means, Kwok W. Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Federal Communications Commission Office of Engineering & Technology, Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), June 2001.

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