Implantable CPW Fed X-Shaped Monopole Antenna For Biomedical Application

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Abstract--- *An implantable CPW fed X-shaped monopole antenna operating in the ISM band (2.4–2.48 GHz) for biomedical applications. The proposed antenna is made compatible for implantation by embedding it in an Al2O3 ceramic substrate. A study of sensitivity of the antenna performance as a function of the dielectric parameters of the environment in which it is immersed was performed. The proposed antenna is simulated using the method of moment's software IE3D by assuming the predetermined dielectric constant for the human muscle tissue, fat and skin and the parameters of the antenna such as return loss, radiation pattern, and VSWR are plotted.*

Keywords--- *Biomedical Applications, Implantable Antenna, ISM Band, Method of Moments, Coplanar Waveguide*

I. INTRODUCTION

PROGRESS in technology becomes an unquestionable prerequisite to meet the increasing demand in medical field for improved health care. To make this possible in quick time, all we need is the knowledge co-ordination of engineering and medicine people. This leads to the development of lots of erudite medical equipment to meet the present-day trends. Exploitation of electromagnetic energy in the field of medicine implicates the usage of antennas of one kind or other, for coupling this energy into human body or into other biological systems.Primarily, medical applications of microwaves can be classified into two categories: therapy and diagnostics. In therapeutically systems, antennas are used as system elements to produce hyperthermia for treating cancer. In diagnostic systems, antennas are used to couple electromagnetic energy in and out of the body. These signals are then examined to study various physiological parameters.

Implantable antenna provides a better means of communication from human body or animal body to external environment. Implantable devices promise better improvements in patient's care and quality of life. This made the research people show keen interest on the study of implantable antennas. These researches result in the innovation of glucose monitoring, pacemaker communication,insulin pumps, endoscopy, retinal prosthesis and blood pressure monitoring in the field of biomedical engineering.Some patients find difficulty in checking up their health condition daily at the hospital. This proposed system may be better replacement for this issue. In such a case,a home care unit can be placed in the patient's house.These units with the accessory networking devices communicate patient condition regularly to the concern person at the hospital .

Medical implant devices had to be magnetically coupled to external equipment's. This magnetic coupling required that the device implanted in the patient should be in very close proximity to the external monitoring device, often necessitating body contact for proper operation. In addition,medical implant devices operated with very slow data rates due to inductive communication, need a lot of time for the required data transfer. This has been changed by establishment of Medical Implant Communication Services (MICS).Therefore, the MICS overcomes the limitations of medical implant devices. An antenna can be designed in either air or the dielectric of the body. If the antenna is designed in air, the antenna's best performance will be achieved when air surrounds the implant. If the implanted antenna is designed in the dielectric of the body, the best performance from the implant will be achieved when the implant is actually inside the body cavity.

Therefore, to design an implanted antenna, it is essential to place the implant in the medium in which it will be expected to operate. In this paper, an implantable antenna is proposed for ISM (Industrial Scientific Medical) applications. The proposed antenna is found to be compact in size and have reasonable return loss of -10dB to cover the ISM band.Furthermore, the return loss property of the antenna is insensitive to the variation in the electrical properties of the human body . The MICS frequency band has been chosen to reduce the wave attenuation in the complex human environment. As a drawback, the use of the MICS band requires electrically very small antennas. Until now, Microstrip (or) PIFA was proposed for implantable devices, which were covered with dielectric materials in the frequency band of 402- 405 MHz [8]. We simulate this antenna which can be effectively be used for 2.45GHz Industrial Scientific Medical (ISM) band.

The use of bigger implantable units restricts the distance of transmission of the signal. This is due to the fact that our body fluids and skin greatly attenuate the signal. This has the adverse effect on transmission power and the coverage. Such problems can be eluded by the usage of repeater units. The radiation characteristics of tissue implantable antenna mounted over human body is simulated using IE3D software.

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II. ANTENNA GEOMETRY

The antenna, presented in this paper, is an implantable CPW fed X-shaped monopole antenna embedded in Al2O3 ceramic substrate. This is due to the fact that X-shaped geometries can be providing significantly larger bandwidths than patch antennas. The top view of the antenna is shown in Fig.1. The antenna design procedure consists of two steps.

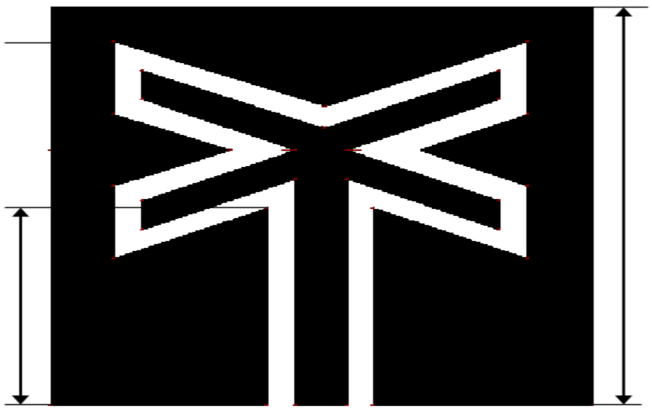

Fig. 1: Proposed Antenna Structure (All dimensions are in mm)

First, the implantable CPW fed X-shaped monopole antenna was designed to operate in the 2.45 GHz for ISM band in free space. Second is to add one layer of liquid, mimicking the dielectric characteristics of human muscle tissue at 2.45 GHz below the substrate. The feeding structure of the X-shaped monopole antenna consists of a Coplanar Waveguide (CPW) with 50 Ω impedance. Matching the mode impedance of the CPW to 50 Ω is obtained by tuning the distance between the tracks and, as well as the width of the tracks as shown in Fig.1. The values for each couple of dielectric constants and related conductivity are reported in Table 1. It is noted that the minor variations reported in Table 1 does not have much effect over antenna behavior.

Table 1: Dielectric Properties of Human Tissues

Tissue	*Permittivity*(ε_r)	*Conductivity*(σ)
Muscle	52.7	1.73
Skin	38	1.46
Fat	5.28	0.10
Bone	18.54	0.80

Theantenna was simulated using Al2O3 ceramic substrate with thickness of 1mm and dielectric constant εr of 9.8 and implanted into muscle, skin, fat and bone with permittivity and Conductivity as tabulated in table1[6]. The proposed antenna thickness and various human tissues thickness is shown in Table.2.

Table 2: Proposed Antenna and Human Tissues Thickness

Human Tissues	*Thickness*
Skin	4mm
Fat	4mm
Antenna	1mm
Muscle	8mm

III. SIMULATION AND RESULTS DISCUSSION

The radiation characteristics of tissue implantable antenna mounted over human body is simulated using IE3D software. The antenna shows the return loss of -20.5 dB for 2.45 GHz, which in turn covers the ISM band as shown in the Fig.3. -10dB impedance bandwidth of the designed antenna is 8.8% for 2.35GHZ to 2.55GHZ. The implanted antenna is simulated in a tissue medium using IE3D software. The VSWR is illustrated in Fig.4. The antenna shows good impedance matching (around 50Ω) with VSWR of 1.2 in the resonant frequency of 2.45GHz. Fig.5 shows effective current distribution of proposed antenna. The radiation characteristics of the proposed antenna such as elevation and azimuth patterns at 2.45 GHz are as shown in Fig.6 and Fig.7 respectively.

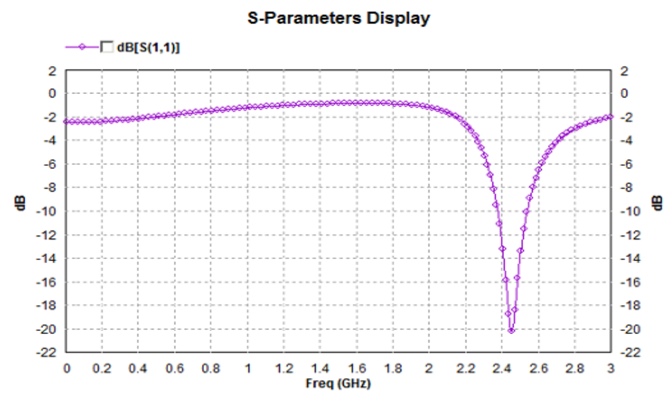

Figure 2: Return Loss for 2.4GHz

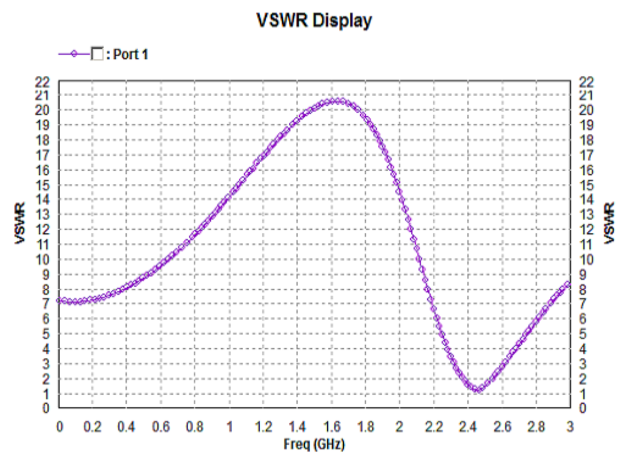

Figure 3: VSWR for 2.4GHz

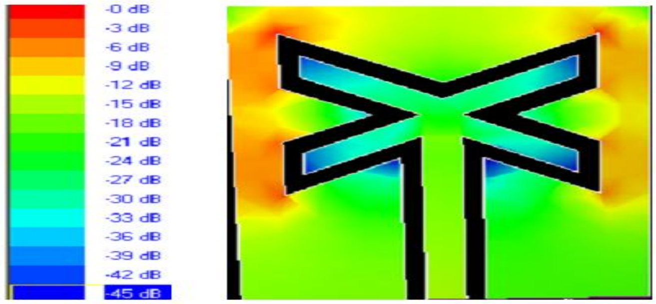

Figure 4: Current Distribution

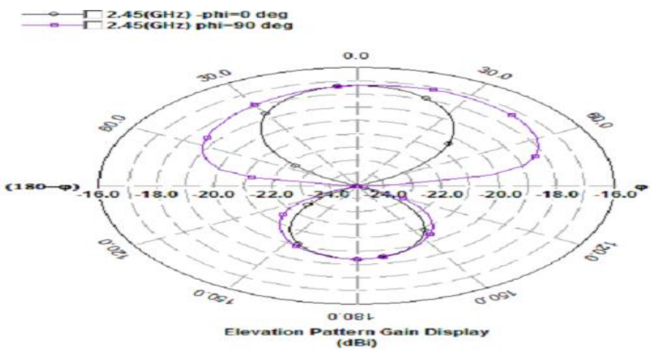

Figure 5: Elevation Pattern for 1.42 GHz

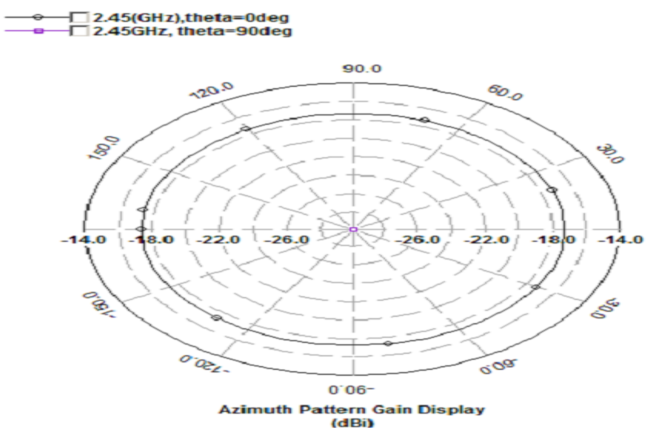

Figure 6: Azimuth Pattern for 1.42 GHz

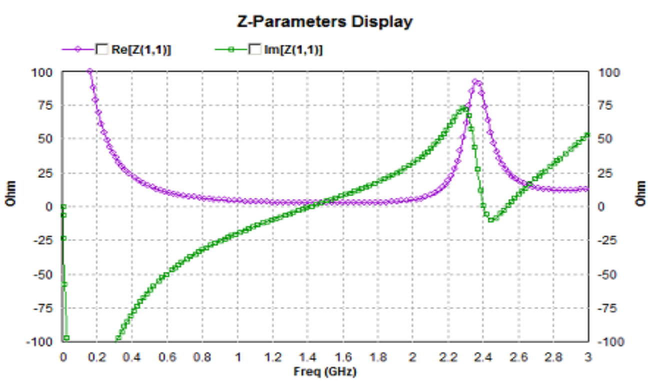

Figure 7: Z-Parameter Analysis

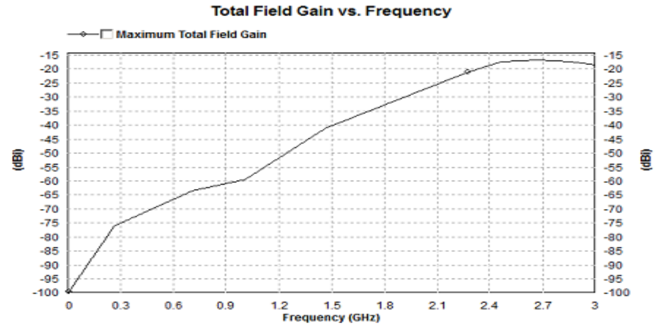

Figure 8: Output Gain Analysis

IV. CONCLUSION

A flexible implantable CPW fed X-shaped monopole antenna for biomedical applications is presented with a compact size of 11x10x1 mm3. The proposed antenna was analyzed by mentor graphics software IE3D. Due to better dielectric constant and quality factor of the ceramic substrates, implantable antenna exhibit lower return loss (-20.5dB), good VSWR (around 1), better impedance matching at 50 Ω with CPW structure. Therefore, the proposed antenna is the suitable structure for ISM band (2.4 – 2.48 GHz) frequency of 2.45 GHz for the field of biomedical engineering applications.

ACKNOWLEDGMENT

I would like to thank especially Mrs.P.Maheswari M.E., and Ms.A.Jeevani Selvabala for the time and guidance given throughout the all carried out works, without forgetting the members of VPMM Educational Institution and all those who contributed , aided for this study in particularly Department members.

REFERENCES

[1] K. Y. Yazdandoost and R. Kohno, "An antenna for medical implant communications system", IEEE Antennas Wireless Propag. Lett., Vol. 6, pp. 392–395, 2007.

[2] Maria Lucia Scarpello, Divya Kurup, Hendrik Rogier, DriesVandeGinste, Fabrice Axisa, Jan Vanfleteren, Wout Joseph, Luc Martens and Gunter Vermeeren "Design of an Implantable Slot Dipole Conformal Flexible Antenna for Biomedical Applications", IEEETransactions on Antennas and Propagation, Vol. 59, No. 10, October 2011.

[3] Li Huang, Maryam Ashouei1, Firat Yazicioglu "Ultra-Low Power Sensor Design for Wireless Body Area Networks: Challenges, Potential Solutions, and Applications".International Journal of Digital Content Technology and its Applications Volume 3, Number 3, Sep 2009.

[4] Tsung-Fu Chien, Chien-Min Cheng, Hung-Chi Yang, Jian-Wei Jiang,and Ching-Hsing Luo "Development of Non superstrate Implantable Low-Profile CPW-Fed Ceramic Antennas", IEEE Antennas and Wireless Propagation Letters, Vol. 9, 2010.

[5] IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300GHz, IEEE Standard C95. pp. 1-1999, 1999.

[6] Italian National Research Council, Institute for Applied Physics, "Dielectric properties of body tissues", http://niremf.ifac.cnr.it

[7] T. Karacolak, A. Z. Hood, and E. Topsakal, "Design of a dual-band implantable antenna and development of skin mimicking gels for continuous glucose monitoring", IEEE Trans. Microwave Theory Tech., Vol. 56, No. 4, pp. 1001–1008, Apr. 2008.

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