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Design and Analysis of MPAT for Biomedical Applications

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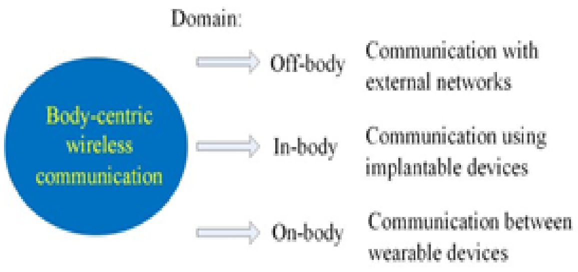
ABSTRACT

The development of new wireless technologies for healthcare applications has attracted a great deal of attention from both academic and industrial researchers, due to the need in the aging population in the world and the associated rise of healthcare costs with demand on hospital resources. An implantable antenna is the key component of radio frequency linked telemetry devices. In proposed work, the Liquid level of Lungs is measured to find the patient health through wireless transmission. The Return loss plays the major role in providing the affected person status. The benefits include more secure and safe access in the healthcare environment, which easily identify patient's condition with regular medications at low risk of error. The human body implantable antenna designed with wireless transmission which works in 2.4GHz frequency. The HFSS (High Frequency Structure Stimulator) is a commercial and industrial analysis Software gives greater accuracy in determining the antenna parameters.

Keywords: Implantable antenna, Miniaturized antenna, Lungs, FR4_ADK, Teflon(tm), Biomedical telemetry and Coaxial feeding.

1. Introduction

The microchip patch antenna is one of rapid development in wireless technologies, due to its compact shape, light weight, less complexity, easy to implement and conformability. Wireless communication is making way into every aspect of human life. Body-centric wireless communication systems (BWCS) are emerging as focal point for future communication. It consists of on-body, off-body and in-body communications. On-body communication means communication between wireless/wearable devices. Off-body communication is said to be as communication from off- body to an on-body device. In-body can be clarified as communication to an implantable device.



Implantable Medical Devices (IMDs) have the capability to communicate wirelessly with an external device. These IMDs are receiving great attention for obtaining both real time and stored physiological data in biomedical telemetry. Typically, radio-frequency link and inductive link are the two kinds of link for biomedical communications. An inductive link is a short-range communication channel requiring a coil antenna of the external device to be in close proximity to the IMD. Other hand, communications via far-field RF telemetry have advantages, such as achieving longer distances and higher data rates. In this connection, RF-linked is used for implantable biomedical devices. The IEEE 802.11(b) and 802.11(g) standards utilizes 2.4GHz ISM band. The frequency band is license-free, hence the WLAN equipment will suffer interference from microwave ovens, Bluetooth devices and other appliances that use this same band. The 802.11a standard uses the 2.4 GHz band which supports high-speed WLAN.

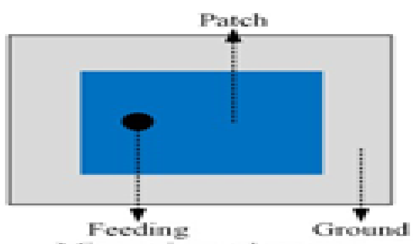
In this paper, researches on implantable antennas for wireless biomedical devices are reviewed and summarized. The paper is organized as follows. In Section II, the requirements related to implantable antenna are briefly given. In section III, Implantable Antenna Design and Measurement. In section IV, the result and their analysis are briefly discussed. In section V, concluding and remarks are given with references.

2. REQUIREMENTS RELATED TO THE IMPLANTABLE ANTENNA DESIGN

The implantable antennas must consider many kinds of requirements that include miniaturization, patient safety, communication ability, biocompatibility, power consumption and lifetime of the devices and circuits.

A. Miniaturization

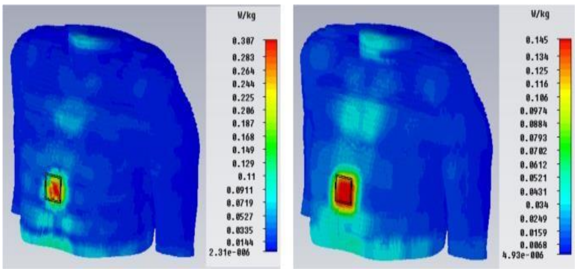
One of the basic and key requirements for biomedical devices. In this condition, miniaturization for implantable antenna design is very crucial and is becoming one of the greatest challenges in the implantable antenna design. Implantable antennas will occupy much space of biomedical devices as implantable devices operate at very low frequency, typically at medical implant communications service (MICS) band (402-405MHz) or medical device radio communications service band (Med Radio, 401MHz – 406MHz).



Microstrip patch antenna

B. Safety Considerations

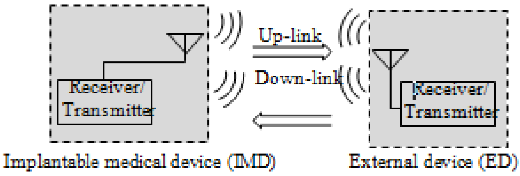
Specific absorption rate (SAR): SAR values are limited to preserve patient safety. Two standards are referenced at this point. The IEEE C95.1-1999 standard restricts the SAR averaged over any 1 g of tissue in the shape of a cube (1-g average SAR) to less than 1.6 W/kg. The IEEE C95.1-2005 standard restricts the SAR averaged over any 10 g of tissue in the shape of a cube (10-g average SAR) to less than 2 W/kg.



A temperature increase of body tissues can be caused by the absorbed power from an electromagnetic field. It is very important that the temperature of the tissue surrounding the implanted device does not increase more than 1-2 ℃.

C. Wireless communication ability

Typically, implantable antennas act as transmitting antennas and exterior antennas act as receiving antennas. And this transmission is defined as up-link transmission.



D. Biocompatibility issue

Implantable devices must be biocompatible for long-term operation in order to preserve patient safety. There are two typical approaches to address the biocompatibility issue for practical applications, one is to design antennas directly on biocompatible materials such as Macor, Teflon, and Ceramic Alumina, the other one is to encase the implantable antenna with a thin layer of low-loss biocompatible coating. For the first approach, it is easy to design implantable antennas when biocompatible materials are considered at first. The other one is to encase the proposed implantable antenna with a thin layer of low-loss biocompatible coating.

3. DESIGN AND MEASUREMENTS

A. Antenna Design

Implantable antenna design is used for the various biomedical applications, the commercial simulation software such as High Frequency Structure Simulator (HFSS) is used for design and stimulation. The antenna is designed, mainly to measure the liquid level rise in lungs. Implantable antenna substrate made of FR4ADK substrate which helps in providing in the higher efficiency of antenna without affecting the human body. Coaxial feeding technique is used for the feed up of MPAT. The front and 3D view of the designed microstrip antenna is shown in figure 1.1 and 1.2.

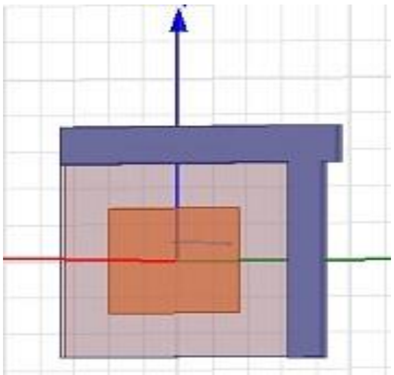


Fig1.1 Front View of structural designed MPAT

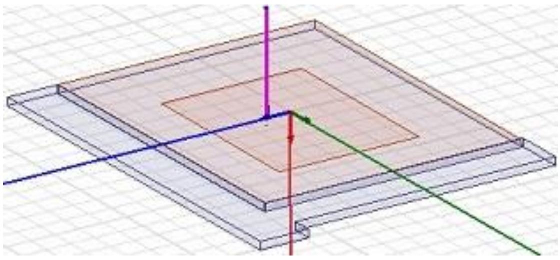
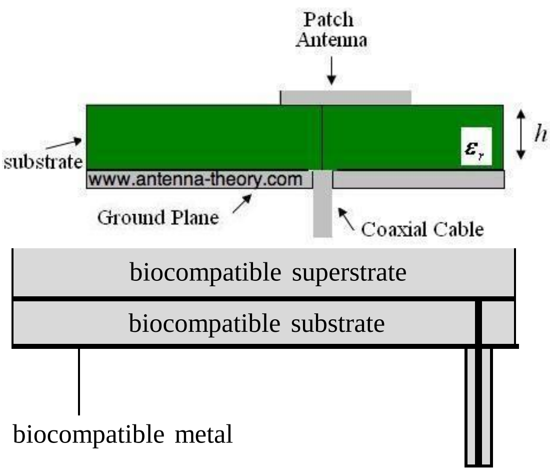


Fig 1.2 3D-View of the Designed antenna with the coaxial feed

B. Antenna measurement

The designed antenna consist of microstrip patch, FR4ADK substrate, Coaxial feed made of Teflon(tm) and vacuum box are measured.



The square patch have been placed over substrate where PatchX-37.26mm and PatchY-28.83mm.Fig1.3.

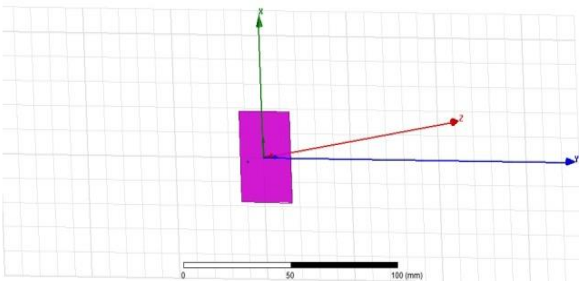


Fig 1.3-3D View of Patch

The FR4ADK substrate have (l)*(b)*(h) where the Substrate X=65.5mm, Substrate Y=52.8mm, Substrate H=1.6mm. Fig 1.4.

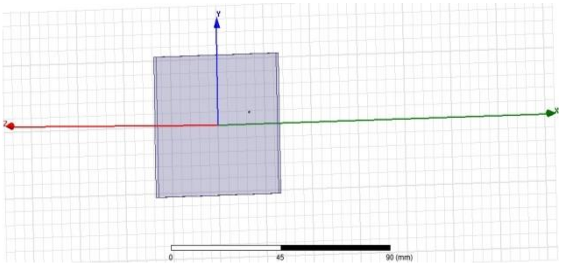


Fig 1.4-3D View of FR4ADK Substrate

The Coaxial feed is made up of Teflon(tm) which is very thin-low loss material and easily biocompatible. Coaxial Inner Radius=0.102mm, Coaxial Outer Radius=0.347mm and Feed Length=20.41mm.Fig1.5.

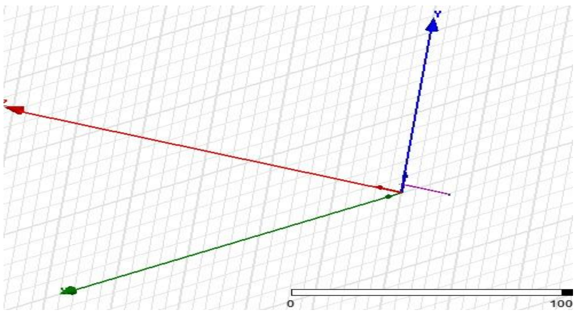


Fig 1.5 Coaxial Feed without Antenna surfaces

4. RESULTS & DISCUSSION

The simulation results for the proposed antenna gives the various basic parameters measured in the antenna design. Through the proposed system the Return Loss is reduced, Gain is increased and Efficiency of the antenna is high with Directivity.

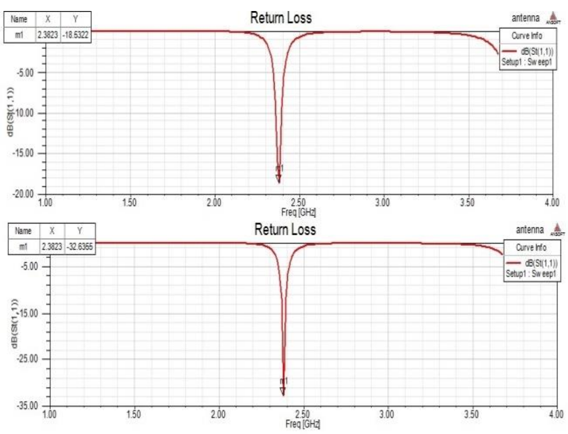


Fig 4.1-Return Loss Comparison of the Simulated Antenna

4.1 Return Loss

The practical circuit realization suffers with the mismatch between the available source power and the power delivered. This is known as return loss. Return loss can be expressed in terms of the reflection coefficient "Γ" (Figure 4.1) shows the return loss of the studied microstrip patch antenna, obtained from the simulation using the HFSS software [12]. The return losses of the antenna works at 2.4GHz where the -32.6355db for not affected lungs and infected lung has -18.6322db.

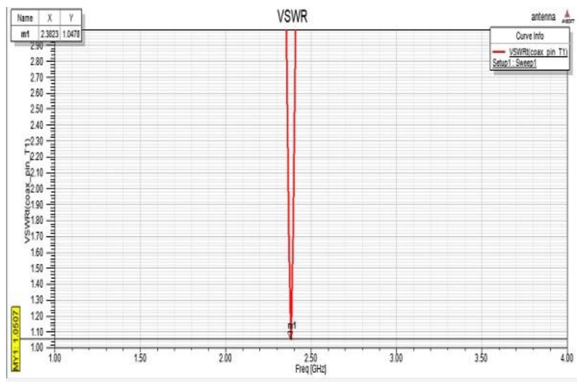
$$\mathbf{RL=-20\log_{10}(P_i/P_r)}$$

4.2 VSWR

The voltage standing wave ratio (VSWR) is a crucial parameter in antenna design, which means that if the transmission line is concluded with a mismatch in impedance, a portion of entered power is reflected back down, in which case the incident signal will be mixed with the reverse signal. This causes a voltage standing wave pattern, in which the ratio of maximum to minimum voltage is known as VSWR.

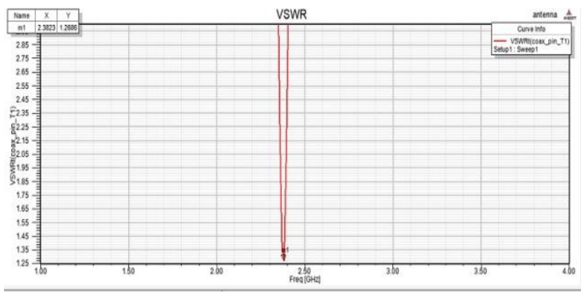
$$\mathbf{VSWR=(1+\acute{\Gamma})/(1-\acute{\Gamma})}$$

Where Ѓ =Reflection coefficient



4.2(a) VSWR results of Non-Affected Lungs

The VSWR of affected lungs is 1.2656. The changes in VSWR shows increase liquid level in lungs.



4.2(b) VSWR results of Affected Lungs

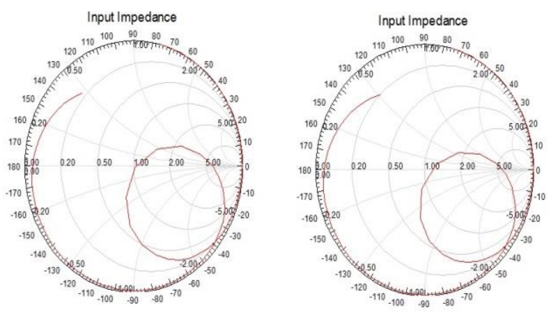


Figure 4.3-2D Radiation Patterns of the Simulated Antenna

4.3 Radiation Pattern

The term radiation pattern refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source. Radiation pattern is the graphical representation radiation properties of the antenna and it shows the variation of power radiated by the antenna as a function of the direction. The radiation pattern also represents the relative strength of the radiated field in different directions from the antenna, at a constant distance.

Since a microstrip patch antenna radiates normally to its patch surface, the radiation patterns of the antenna are almost Omni-directional which allows us to use this antenna for mobile applications. The far field and near field 2D radiation patterns for the proposed patch antenna are shown in figure 4.3.

4.4 Gain

The 3D Gain plot is shown in figure 4.4. The calculated gain of the non-affected antenna is 6.63dB but in infected lungs it differs 6.81dB.

$$\text{Gain} = 4\Pi U/P_{in}$$

U is radiation intensity
Pin is total input power.

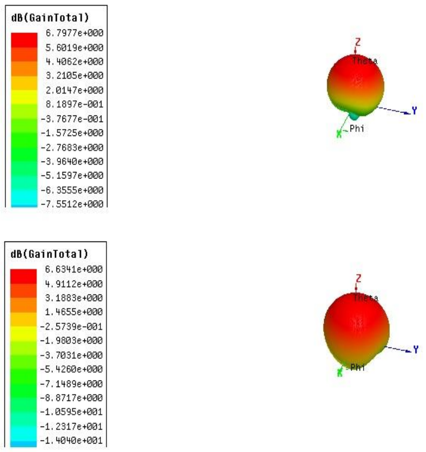
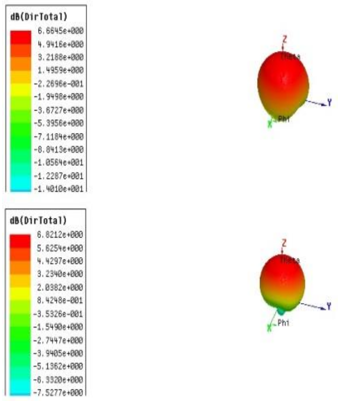


Figure 4.4 3D - Gain Total of the Simulated Antenna

4.5 Directivity

It is relative measure of an antennas ability to direct RF energy in particular direction. It is defined as how much power is transmitted in the direction of peak radiation to that of an isotropic source. The 3D Directivity plot is shown in figure 4.5. The calculated directivity of non-affected lungs is 6.66dB but the infected lungs having the 6.71dB.



4.5 3D-view of Directivity of Designed Antenna

4.6 Parameters Measured From Antenna Designed

Table III- Result Analysis of Various Lung State

Parameters	Non-Affected lungs	With affected lungs
Return Loss	-32.86db	-18.35db
Gain	6.6db	6.7db
VSWR	1.04	1.12
Directivity	6.6db	6.8db

5. CONCLUSIONS

The overview of the requirements related to the implantable antenna design has been provided. Meanwhile, different kinds of miniaturized techniques, simulation and test methods for implantable antenna design have been studied; antenna types, operating frequency bands, safety considerations, design environments, and testing methods have been reviewed. In practice, implantable antennas are integrated with other biomedical circuits or sensors as other components may affect the performance of the implantable antennas. Also, low power consumption is a big concern in order to extend the lifetime of the implantable devices and maintain the safety considerations of patients. Antenna dimensions, radiation efficiency, power supply (feeding), communication distance, return loss, gain, directivity and so on should be considered as a whole to design implantable devices.

REFERENCES

[1] Changrong Liu, Yong-Xin Guo and Shaoqiu Xiao, "A Review of Implantable Antennas for Wireless Biomedical Devices," *Forum for Electromagnetic Research Methods and Application Technologies (FERMAT)/*2015.

[2] Kiourti.A and K. S. Nikita, "A Review of Implantable Patch Antennas for Biomedical Telemetry: Challenges and Solutions," *Antennas Propag. Mag. IEEE*, vol. 54, no. 3, pp. 210 – 228, Jun. 2012.

[3] Prasanna Lakshmi.Y, M.Umamaheswara Rao, B.Suresh Babu, "A Dual band Human Shaped Microstrip Patch Antenna for 2.4 GHz and 5.4 GHz Applications," *International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering* Vol. 3, Issue 3, March 2015.

[4] Kiourti.A, J. R. Costa, C. A. Fernandes, A. G. Santiago, and K. S. Nikita, "Miniature Implantable Antennas for Biomedical Telemetry: From Simulation to Realization," *IEEE Trans. Biomed. Eng.*, vol. 59, no. 11, Nov. 2012.

[5] Konstantinos Psathas, "Design Of Implantable Dual-Band Antenna for Biotelemetry," *National Technical University of Athens, Athens - Greece*, 2012.

[6] Bradley.P.D., "Wireless Medical Implant Technology – Recent Advances and Future Developments," *Esscirc 2011 Proc.*, pp. 37 – 41, 2011.

[7] Skriverviky.A.K. and F.Merli, "Design strategies for implantable antennas," Antennas *Propag. Conf. Lapc 2011 Loughb.*, pp. 1 – 5, Nov.2011.

[8] Kiourti.A., M. Tsakalakis, and K. S. Nikita, "Parametric Study and Design of Implantable PIFAs for Wireless Biotelemetry," *Proc. 2nd Icst Int. Conf. Wirel. Mob. Commun. Healthc. Mobihealth 2012 Kos Isl. Greece*, Oct. 2011.

[9] Kiourti.A., K. S. Nikita, and M. Christopoulou, "Performance of a Novel Miniature Antenna Implanted in the Human Head for Wireless Biotelemetry," *IEEE Int. Symp. Antennas Propag. Spokane Wash.*, Jul.2011.

[10] Merli.F, "Implantable Antennas for Biomedical Applications," *Ecole Polytechnique Federale De Lausanne*, 2011.

[11] Kiourti.A and K. S. Nikita, "Miniature Scalp-Implantable Antennas for Telemetry in the MICS and ISM Bands: Design, Safety Considerations and Link Budget Analysis," *Ieee Trans. Antennas Propagation 2011*.

[12] Skriverviky.A.K. and F. Merli, "Design and characterization of bio implantable antennas," *ICECOM 2010 Conf. Proc.*, pp. 1 – 5, Sep. 2010.

[13] Kumar.A., A. Srivastava, I. Galaev, and B. Mattiasson, "Smart polymers: Physical forms and bioengineering applications," *Prog. Polym. Sci.*, vol. 32, no. 10, pp. 1205–1237, 2007.

[14] Yazdandoost.K.Y. and R. Kohno, "An Antenna for Medical Implant Communications System," *Proc. 37th Eur. Microw. Conf.*, pp. 968–971, Oct.2007.

[15] Burgahard.J, C. Campbell, T. Younkin, M. Kuhn, D. Shykind, and J. Maiz, "Biocompatible coatings for Medical Devices," *US 2009/0169714 A1,007*.

[16] Riistama.J, J.Vaisanen, S. Heinisuo, J. Lekkala, and J. Kaihilahti, "Evaluation of an implantable ECG monitoring device in vitro and in vivo," *Eng. Med. Biol. Soc.*, pp. 5703 – 5706, 2007.

[17] Buchegger.T, G. Obberger, A. Reisenzahn, E. Hochmair, A. Stelzer, and A. Springer, "Ultra-Wideband Transceivers for Cochlear Implants,"*Eurasip J. Appl. Signal Process.*, vol. 18, pp. 3069–3075, 2005.

[18] Soontornpipit.P., C. M. Furse, and Y. C. Chung, "Design of Implantable Microstrip Antenna for Communication with Medical Implants," *IEEE Trans. Microw. Theory Tech.*, vol. 52, no. 8, pp. 1944–1951, Aug.2004.

[19] Kim.J and Y. Rahmat-Samii, "Implanted Antennas Inside a Human Body: Simulations, Designs and Characterizations," *IEEE Trans. Microw. Theory Tech.*, vol. 52, no. 8, pp. 1934–1943, Aug. 2004.

[20] Garag R. Bhartia P. Bahl I. and ITTIPIBOON A.(2001), "Microstrip Antenna Design Handbook", *Artech House, Norwood, MA, USA.*