UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPLANTABLE IN BODY ANTENNA DESIGN AT MEDICAL IMPLANT COMMUNICATION SERVICE BAND FOR TELE-MEDICINE APPLICATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunication) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

……

(Mr. Adib Bin Othman)

ABSTRAK

Projek ini difokuskan pada kajian parameter antena dan kesan radiasi dalam model lengan manusia yang dihasilkan oleh "implantable flexible hexagonal shape patch antenna". "This implantable hexagonal shape patch antenna" adalah fleksibel dan sesuai untuk aplikasi yang boleh pakai. Ciri khas antena ini adalah ia adalah fleksibel dan boleh pakai ke mana-mana bahagian model lengan manusia yang beroperasi di 402 - 405 "MHz MICS (Medical Implant Communication Service)" mengenai pengoptimuman antena ditanam "implantable antenna" yang dipilih untuk "bandwidth", "return loss", "radiation" yang menunjukkan "efficiency" antena yang dicadangkan. "This flexible hexagonal shape patch antenna" diukur dalam dua tisu yang berbeza di dalam model lengan manusia yang lemak dan otot dibentangkan dalam kertas ini. Terdapat dua keadaan pemerhatian iaitu "antenna in free space condition" dan "attach to human arm model". Kedua-dua syarat dianalisis, dari segi prestasi antena seperti "frequency", "return loss", "realized gain", "directivity" dan "efficiency". Selepas itu, simulasi dilakukan dalam jarak dekat di dalam model lengan manusia yang sepadan dengan"antenna field region" dan "size of antenna's reactive near-field" yang berpuas hati menjadi faktor penting dalam penilaian operasi yang boleh diterima dalam badan. "For the implanted hexagonal shape patch antenna in muscle layer, the resonant frequency is 403 MHz and the return loss is -33.937dB. The realized gain is 0.91".Maksimum 1.6 W/kg SAR ialah 1.52 untuk 1g tisu. Oleh itu, parameter tersebut berpuas hati. Antena yang dicadangkan diuji dalam pelbagai keadaan lenturan. Hasil kajian ini membantu jurutera dan doktor menilai antena untuk kegunaan "implantable flexible hexagonal shape patch antenna "dalam aplikasi perubatan. Lebih khusus lagi, kerja ini memberi tumpuan kepada antena untuk diintegrasikan ke peranti implan dengan keupayaan telemetri data jarak jauh.

ABSTRACT

This project is focused on the study of the antenna parameters and the radiation effect in the human arm model produced by the implantable flexible hexagonal shape patch antenna. This implantable hexagonal shape patch antenna is flexible and suitable for wearable applications. The special feature of this antenna is it is flexible and wearable to any part of human arm body which operates at 402 - 405 MHz MICS (Medical Implant Communication Service) on the optimization of the chosen implantable antenna for bandwidth return loss, radiation which shows the efficiency of the proposed antenna. This flexible hexagonal shape patch antenna is measured in two different phantom tissues inside human arm model which are fat and muscle are presented in this paper. There are two conditions of observation which are antenna in free space condition and attach to human arm model condition. Both conditions were analyzed, in term of antenna performance such as frequency, return loss, realized gain, directivity, and efficiency. After that, the simulation is carried out in the proximity inside human arm model which commensurate with the antenna field region and the size of antenna's reactive near-field that is satisfied to be an important factor in the evaluation of an acceptable in body operation. For the implanted hexagonal shape patch antenna in muscle layer, the resonant frequency is 403 MHz and the return loss is -33.937dB. The realized gain is 0.91.The maximum 1.6 W/kg SAR is 1.52 for 1g of tissues. Therefore, those parameters are satisfied. The results of this study are helpful to engineers and doctors evaluating antennas for the use of flexible hexagon patch antenna in medical application. More specifically, this work focuses on antennas to be integrated into implantable devices with far-field data telemetry capabilities.

DEDICATION

I dedicate this project to God Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this project and on his wings only have I soared. I also dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving mother, Mages Wary whose words of encouragement and push for tenacity ring in my ears. For my mom, without her I would not be here. My brother, Thana Seelan have never left my side and are very special. For they have raised, cherished, and loved me, according to the will of my Grandmother in heaven. From day one loving words, actions, and intentions have been poured out on me by their hands. Thank you. My love for you all can never be quantified

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION

MICS	Medical Implant Communication Service
ISM	Industrial Science and Medical
ECG	Electro Cardio Gram
MBAN	Medical Body Area Network
UWB	Ultra-Wide Band
FCC	Federal Communication Commission
WBAN	Wireless Body Area Network
SAR	Specific Absorption Rate
VSWR	Voltage Standing Wave Ratio
CPW	Coplanar Waveguide
MMIC	Monolithic Integrated Circuits
CST	Computer Simulation Technology
DGS	Defective Ground Structure
RL	Return Loss
Eff	Efficiency
E_r	Permittivity

CHAPTER 1
INTRODUCTION

1.0 Introduction

The first chapter is introductory and clearly shows the current state-of-the-art in implantable medical devices for medical telemetry. Essential elements of implantable devices are antennas embedded in such systems, which enable the exchange of data between implantable devices and external environment. Moreover this chapter also explain about problem statement, objectives, scope of work and project schedule.

1.1 Introduction to Title

Recently, medical implantable devices are at the center of much academic and technical research in bioengineering and science. The increasing demand for reducing the need for invasive surgical operations necessitates the use of implanted devices as a part of diagnosis and treatment procedure. In recent years, the application of the implantable antenna for building a communication link between the implanted devices and outside the human body is receiving more attention [1]. The technology can also be used in tracking both animals, humans and gathering their biological information [1]. The implanted antenna is designed to monitor the physiological parameters in human body such as body temperature, blood pressure,

glucose level, etc [1]. The challenges in the way of implantable antennas are power loss in the biological tissues, the effect of the surroundings on the antenna impedance and antenna efficiency, size constraints and the difficulties of having actual measurements with the live tissues [2-4]. Antennas used to elevate cancer tissues temperature are positioned inside or outside the patients' body. The shapes of antennas depend on their locations. Indeed there are antennas implanted internally and others implanted externally [1, 12]. The electrical properties of the body tissues are frequency dependent and should be identified for the frequency of interest. The biological tissues are extremely lossy and this makes it difficult to get a reasonable level of power out of the body. In addition it is required as impedance matching of the antenna inside the human tissue [3-5].

Antennas implanted in a human body are largely applicable to biotelemetry. In order to make practical use of antennas inside a human body, resonance characteristics of the implanted antennas and their radiation signature outside the body must be evaluated through numerical analysis and measurement setup. Most importantly, the antenna must be designed with an in-depth consideration given to its surrounding environment.

Most of the research on microwave antennas for medical applications has focused on producing hyperthermia for medical treatments and monitoring various physiological parameters [7-8]. Antennas applied to elevate the temperature of cancer tissues are located inside or outside of the patient's body, and the types of antennas depend on the location. For instance, waveguide or low-profile antennas are externally positioned, and monopole or dipole antennas transformed from a coaxial cable are designed for internal use [2], [7]

In addition to medical therapy and diagnosis, telecommunications are regarded as important functions for implantable medical devices (pacemakers, defibrillators, etc.), which need to transmit diagnostic information [9]. In contrast to a number of research accomplishments related to hyperthermia, studies on antennas

used to build the communication links between implanted devices and exterior instrument for biotelemetry [2].

Several frequency bands have been identified for research and commercialization of BAN communication systems, such as the 402–405 MHz Medical Implant Communication Services (MICS) band [8], the 2.4–2.48 GHz industrial, scientific, and medical (ISM) band [4], the 3.1–10.76 GHz ultra-wide band (UWB) range [10], and others. More recently, a new medical BAN (MBAN) band, which operates from 2.36 to 2.4 GHz, has been considered by the Federal Communication Commission (FCC) for its clean spectrum and low interference sources [6].

Micro strip antennas, also referred to as patch antennas, are low profile, comfortable to planar and non-planar surfaces mechanically robust when mounted on rigid surfaces, compatible with MMIC (Monolithic Microwave Integrated Circuits) designs. Micro strip antennas have a number of advantages over other antennas; they are inexpensive, lightweight and easy to integrate with accompanying electronics. In the wireless communication area, micro strip antennas are of interest for implantable applications because of their flexibility in design, conformability and shapes.

In this study, we designed a hexagonal shape patch antenna on "Rogers 3010" substrate antenna. It is designed with the concept of micro strip antenna which light weight, thin and flexible that suitable for implantation into human body for communication. The antenna operates for Medical Implant Communication Services (MICS) band at 402 MHz to 405 MHz .The study focuses on five important parameters of the antenna i.e. Return loss, gain, directivity, efficiency, low Specific Absorption Rate (SAR) for analyzing the performance in human body vicinity.

As the conclusion, a micro strip antenna will help in the future as a brainstorm to build a communication link with implanted devices to increase the capability of diagnosis and/or treatment and reduces the need for invasive surgical

operations. It is pivotal to establish a low profile, small, safe and cost effective antenna in order to be utilized inside a realistic human body environment.

1.2 Problem Statement

Currently, the medical treatments facing difficulties in monitoring patient healthcare information by using wire transmission due to its limited in communication range. Mostly, the challenges in the way of implantable antennas are power loss in the biological tissues, the effect of the surrounding in the antenna impedance and antenna efficiency, size constraints and the difficulties of having actual measurement with the live tissues. So this proposed antenna-enabled biotelemetry for implants is gaining considerable attention in an attempt to overcome the limitations of inductive biotelemetry related to low data rate, and restricted communication range. Implantable antenna design attracts high scientific interest to deal with the challenges of miniaturization, biocompatibility, impedance-matching, reliable data exchange and patient safety. The healthcare monitoring system, with a wireless implantable device is to provide reliable information from inside of the human body to an external Base Station (BS) or subsequently a smart phone. Physiological signals are obtained by means of appropriate transducers, then post-processed, and eventually transmitted to exterior monitoring/control equipment for analysis by the operator.

1.3 Objectives

The main objectives of the research are:-

a. To design a patch antenna with low profile, small, safe and cost effective which implant into human body for several medical applications.
b. To propose of simplified geometries for low-profile antennas implanted in the human body tissue which is fat and muscle.