UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SURFACE MOUNTED ON 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

Antena yang dipasang pada badan digunakan dalam biotelemetri dan "walkie-talkies". Pemancar biotelemetri digunakan untuk ujian manusia dan haiwan untuk merekodkan data fisiologi dan lain-lain dengan bebanan minimum untuk subjek ujian. Pada masa kini, peranti yang direka untuk memantau data fisiologi dari tubuh manusia mempunyai janji besar untuk memberikan sumbangan besar kepada pencegahan penyakit, diagnosis, dan terapi. Projek ini difokuskan pada kajian parameter antena dan kesan sinaran dalam model lengan manusia yang dihasilkan oleh "microstrip flexible patch antenna" yang dipasang pada permukaan badan. "Microstrip flexible patch antenna" ini adalah fleksibel dan sesuai untuk aplikasi yang boleh dipakai. Ciri khas antena ini adalah fleksibel dan boleh diletak di mana-mana bahagian badan lengan manusia yang beroperasi di 402-405MHz MICS (Medical Implant Communication Service) " mengenai pengoptimuman permukaan yang dipilih dipasang pada antena badan untuk "bandwidth", "return loss", "radiation" yang menunjukkan "efficiency" antena yang dicadangkan. "Microstrip patch antenna" yang fleksibel diukur dalam bahagian atas kulit dari model lengan manusia yang dibentangkan dalam kertas ini. Terdapat dua keadaan pemerhatian yang merupakan antena dalam keadaan ruang bebas dan melekat pada keadaan model lengan manusia. Kedua-dua keadaan dianalisis, dari segi prestasi antena seperti "frequency", "return loss", "realized gain", "directivity" dan "efficiency". Selepas itu, pengukuran dilakukan dalam jarak dekat 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 badan yang boleh diterima."Its radiation characteristics, return loss, gain, and polarization" telah diperiksa apabila ia digunakan dalam keadaan ruang bebas dan atas kulit untuk tujuan perubatan.

ABSTRACT

Body-mounted antennas are used in biotelemetry and walkie-talkies. Biotelemetry transmitters are applied to human test subjects and animals in order to record physiological and other data with minimum encumbrance for the test subject. Nowadays, the devices designed to monitor physiological data from the human body have great promises to provide major contributions to disease prevention, diagnosis, and therapy. This project is focused on the study of the antenna parameters and the radiation effect in the human arm model produced by the surface mounted on body microstrip flexible patch antenna. This microstrip patch antenna is flexible and suitable for wearable applications. The special feature of this antenna is it is flexible and can attach to any part of human arm body which operates at 402 - 405 MHz MICS (Medical Implant Communication Service) on the optimization of the chosen surface mounted on body antenna for bandwidth, return loss, radiation which shows the efficiency of the proposed antenna. This flexible microstrip patch antenna is measured on skin surfaces as a part of the human arm model which are presented in this paper. There are two conditions of observation which are an 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 of 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. Therefore, those parameters are satisfied. Its radiation characteristics, return loss, gain, polarization has been examined which are the issues when it is use in free space and on body surface for medical purpose. One of the advantages of these characteristics is once the antenna is flexible and bends in any condition on human body then the specific absorption rate can be reduced.

DEDICATION

I dedicate this project to God who has provided all that was needed to complete this project and the program for which it was undertaken for. There was never lack or want. Throughout this entire study, He took care of everything that would have stopped me in my tracks and strengthened me even through my most difficult times. I also dedicate this project to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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My thanks and appreciations also go to my friends in developing the project and people who have willingly helped me out with their abilities. I have to appreciate the guidance given by other supervisor as well as the panels especially in our project presentation that has improved our presentation skills thanks to their comment and advices.

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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

This chapter elaborate on introduction to antenna design for mounting over the surface of human body. Moreover this chapter also explain about problem statement, objectives, scope of work and thesis organisation.

1.1 Introduction to Title

Telemedicine is becoming increasingly utilized by health care providers due to the growing demand for remote monitoring of human vital signs. Telemedicine applications include but not limited to monitoring of seniors, recovery tracking of patients, monitoring the health parameters of astronauts and athletes, and E-psychiatry [1]. The health parameters that may be forwarded to remote stations via wireless transmission (off body mode) range from basal body temperature, heart rate, respiratory rate, blood pressure, to glucose levels and Electro Cardio Gram (ECG) waveforms.

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 [2], the 2.4–2.48 GHz industrial, scientific, and medical (ISM) band [3], the 3.1–10.76 GHz ultra-wide band (UWB) range [4], 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.

In general, traditional micro strip antennas offer favorable characteristics in terms of radiation pattern (uni-directional which is preferred in telemedicine application to minimizes the user's exposure to EM radiation). Furthermore, micro strip antennas have the merits of low profile construction, low fabrication complexity and low cost; however, they suffer from a very narrow bandwidth which is a function of the substrate thickness and dielectric constant [5]. Flexible materials have been widely used as substrate to design wearable antennas. These substrates are robust, lightweight and can withstand mechanical strains up to a certain extent without permanent deformation [6]. In Wireless Body Area Network (WBAN) applications, single or multiple antennas are mounted as transceiver nodes on human body. These transceiver nodes communicate with one another or some remote server for sending data depending on application.

In this study, we designed a flexible antenna on Rogers 3010 substrate antenna. It is designed with the concept of micro strip antenna which is light weight, thin and flexible that suitable for mounting over the surface of human body for communication services. The antenna operates for Medical Implant Communication Service (MICS) band at 403 MHz. The study focuses on five important parameters of the antenna such as return loss, gain, directivity, efficiency and Specific Absorption Rate (SAR) for analyzing the performance in human body vicinity.

1.2 Problem Statement

Mostly, the flat antenna design facing a problem due to its unbalance bending structure not compatible with movement of human body. Thus it gives low data transfer and limited in communication range. The ideal surface mounted antenna need in design to avoid limitation while measuring the data of human vital signs.

1.3 Objectives

a) To design an antenna to be comfortable and conformal to the body shape.
b) To analyse the antenna performance by simulating return loss, gain, directivity, efficiency and Specific Absorption Rate (SAR) which can well function on Medical Implant Communication Service (MICS) frequency band.

1.4 Project Scope

The scope of work in this project is to design a compatible antenna which can mounted on surface body for telemetry application. Such antennas operate in close proximity to the human body, the loading effect due to lossy tissue makes the design of a high radiation efficiency antenna challenging when it is also desirable for it to possess lightweight and low-profile characteristics [7]. At the same time, the impact of such antennas on human tissue also needs to be addressed, such as the maximum allowed specific absorption rate (SAR) should be below than 1.6 W/Kg for 1g of tissue. An antenna is design to be operating at frequency range of 402-405 MHz, Medical Implant Communication Service (MICS) for short range communication system in medical application services. The antenna dimension would be 200mm x 150mm x 1.6mm and substrate used was Rogers 3010 with permittivity of 10.2. The design antenna tested in simulation, on skin layer with different bending angle's which is 0°, 20° and 35°.

1.5 Thesis Organisation

Chapter One 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. Challenges faced by the designer of implantable antennas are considered and the subject of this thesis is presented, which is the design of an optimized implantable antenna, for wireless radiation dosimetry, for usage within external-beam radiotherapy.

Chapter Two summarizes the theoretical knowledge and research background required to design an surface mounted antenna for medical purposes. This chapter describes the basic operating principles of microstrip as well as the Antenna Performance Parameters are described following by standard Miniaturization techniques. Finally, several antenna designs in Literature Review are reported as well.

Chapter Three analytical studies of three antenna design parameters and characteristic of substrates. Finally, a brief description about the Simulation Software CST that is used in this paper is reported.

Chapter Four presents an optimized three analytical parametric studies of three antenna designs which operate at 402 - 405 MHz MICS band.

Chapter Five the conclusions from the work that has been carried out throughout the project are presented and the results are discussed. Further improvements of the proposed miniaturized antennas are considered and future developments are proposed.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

The literature review is one of the author's methodologies to enhance the understanding of the field research. Besides that, literature reviews are made for the support of the arguments that are made during this research. On the other hand, this literature review summarizes text of several scholarly papers, which include the current knowledge including substantive findings, as well as theoretical and methodological contributions to a Chapter 3 and Chapter 5. Apart from that, the literature review is carried out in order to enable the reader to this section if there is confusion and misunderstanding of some of the terms that are found throughout this research.

2.1 Introduction to Antenna

An antenna is a transducer, which converts electrical power into electromagnetic waves and vice versa. An antenna can be used either as a transmitting antenna or a receiving antenna. A transmitting antenna is one, which converts electrical signals into electromagnetic waves and radiates them. While the receiving antenna is one, which converts electromagnetic waves from the received beam into electrical signals. In two-way communication, the same antenna can be used for both transmission and receiver [8], [9].

2.2 Properties of Antennas

The basic communication parameters are discussed in this chapter to have a better idea about the wireless communication using antennas. The wireless communication is done in the form of waves. Hence, we need to have a look at the properties of waves in the communications. In this part, we are going to discuss about the following parameters [10]:-

2.2.1 Antenna Gain

The parameter that measures the degree of directivity of antenna's radial pattern is known as gain. An antenna with a higher gain is more effective in its radiation pattern. Antennas are designed in such a way that power raises in wanted direction and decreases in unwanted directions.

$$G = P_{ra} / P_{rf} \quad (2.1)$$

Where;

P_{ra} = Power radiated by antenna

P_{rf} = Power radiated by reference antenna

2.2.2 Directivity

The directive of an antenna is defined as the measure of concentrated power radiation in a particular direction. It may be considered as the capability of an antenna to direct radiated power in a given direction. It can also be noted as the ratio of the radiation intensity in a given direction to the average radiation intensity. Bandwidth is one of the desired parameters to choose an antenna. It can be defined as the range of frequencies over which an antenna can properly radiates energy and receives energy.

$$D = \frac{1}{\mathbf{1}/\mathbf{4\pi} \int_0^{2\pi} \int_0^{\pi} |\boldsymbol{F}(\boldsymbol{\theta}, \emptyset)|^2 \sin \boldsymbol{\theta} d\boldsymbol{\theta} d\emptyset} \quad (2.2)$$

Where;

F = frequency

$\emptyset$ = Angle of radiation intensity

2.2.3 Bandwidth

Is another fundamental antenna parameter. Bandwidth describes the range of frequencies over which the antenna can properly radiate or receive energy. Often, the desired bandwidth is one of the determining parameters used to decide upon an antenna. For instance, many antenna types have very narrow bandwidths and cannot be used for wideband operation.

Bandwidth is typically quoted in terms of VSWR. For instance, an antenna may be described as operating at 100-400 MHz with a VSWR<1.5. This statement implies that the reflection coefficient is less than 0.2 across the quoted frequency range. Hence, of the power delivered to the antenna, only 4% of the power is reflected back to the supply source. Alternatively, the return loss is S_{11} = 20*log(0.2) = -13.98 dB.

2.2.4 Polarization

An electromagnetic wave launched from an antenna may be polarized vertically and horizontally as shown in Figure 2.1. If the wave gets polarized in the vertical direction, then the E vector is vertical and it requires a vertical antenna. If vector E is in horizontal way, it needs a horizontal antenna to launch it. Sometimes, circular polarization is used, it is a combination of both horizontal and vertical ways.