IMPLEMENTATION OF VARIOUS BIO-MATERIAL AS DOUBLE NEGATIVE METAMATERIAL BUILD IN FOR ULTRA-WIDEBAND (UWB) ANTENNA DESIGN

SYAHIRAH BINTI AHMAD SARBAINI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPLEMENTATION OF VARIOUS BIO-MATERIAL AS DOUBLE NEGATIVE METAMATERIAL BUILD IN FOR ULTRA-WIDEBAND (UWB) ANTENNA DESIGN

SYAHIRAH BINTI AHMAD SARBAINI

This Report Is Submitted in Partial Fulfillment of Requirements For The Bachelor Degree of Electronic Engineering (Telecommunications Electronics) With Honours

Faculty of Electronics and Computer Engineering

Universiti Teknikal Malaysia Melaka

June 2016

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : **IMPLEMENTATION OF VARIOUS BIO-MATERIAL AS DOUBLE NEGATIVE METAMATERIAL BUILD IN FOR ULTRA WIDE-BAND (UWB) ANTENNA DESIGN**

.....

Sesi Pengajian :

1	5	/	1	6

Saya SYAHIRAH BINTI AHMAD SARBAINI

.....

(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐ **SULIT*** *(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ **TERHAD**** **(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ **TIDAK TERHAD**

Disahkan oleh:

_____ _____

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

DECLARATION

I hereby declare that the work in this project is my own except for summaries and quotations which has been duly acknowledge.

Signature : _____

Author : SYAHIRAH BINTI AHMAD SARBAINI

Date : _____

APPROVAL

"I acknowledge that I have read this report and in my opinion, this thesis is sufficient in term of the scope and quality for the award of Bachelor Degree in Electronic Engineering (Telecommunication Electronics) With Honours."

Signature : _____

Supervisor's Name : ADIB BIN OTHMAN

Date : _____

DEDICATION

Special dedication to my beloved parents,

En. Ahmad Sarbaini b. Mohamed & Pn. Maziah bt Manap

My supporting siblings:

Shahril b. Ahmad Sarbaini

Sabtiyah bt. Ahmad Sarbaini

Syasya bt. Ahmad Sarbaini

Syazana bt. Ahmad Sarbaini

To my supervisor

Adib b. Othman

My friends and my fellow lecturers

Thank you for all your care, support and believe in me

ACKNOWLEDGEMENT

The completion of this report has given me much pleasure and satisfaction. A salute to University Teknikal Malaysia Melaka (UTeM) for conducting this program for my course Bachelor of Engineering in Electronics (Telecommunication) and incomparable to Allah's blessing.

First and foremost, I would like to extend my deepest gratitude to my supervisor, Adib Bin Othman for giving me such opportunity to be involved with this project with numerous advice and consultations. I've gained a lot of useful knowledge and ideas from his insights.

In addition, many people, especially my classmates and team members; whose have made sort of brilliant ideas and comments on this final project report which has given much inspiration to improve and improvise this report.

I am thankful to the technician PSM Lab, Encik Imran Bin Mohamed Ali and technician Makmal Penyelidikan I, Encik Mohd Sufian Bin Abu Talib. A big contribution from those involved during this PSM program.

ABSTRACT

This project proposed design of a metamaterial antenna on a substrate which the substrate has bio-material properties. A bio-compatible antenna is designed to be implement inside the human body for future telemedicine applications. The antenna is designed to operate on Ultra-Wideband (UWB) for short range communication system in medical application at a frequency of 8.1 GHz. The metamaterial antenna is designed on four different substrates such as Flame Retardant 4 (FR-4), Teflon, Alumina and PDMS in order to test the antenna performances inside the human body. The configurations are simulated and analyzed using Computer Simulation Technology (CST) software. Simulation results show a better performance in terms of gain, directivity and SAR value of the antenna with proposed metamaterial structure. Based on the four different substrates results, it is shown that the Teflon substrates yields better results than other substrates in free space and homogeneous human arm model. The SAR value was reduced from 5.68 W/Kg to 2.91W/Kg when antenna implemented with metamaterial structure. The UWB antenna with proposed metamaterial structure is verified fabrication and validation of antenna performance in the laboratory. The antenna used FR4 as substrate due to limitation of materials, time and cost. The results of return loss for an antenna with metamaterial during simulation operates at 8.1GHz with -64.36 dB while in measurement it operates at 8.5GHz with -25.72 dB. Both results from simulation and measurement shows that the antenna with metamaterial structure has better performance compared to conventional antenna.

ABSTRAK

Projek ini dicadangkan untuk reka bentuk antena metamaterial sebagai substrate (permukaan antena) dengan menggunakan bahan semulajadi sebagai sub - struktur antena. Antena yang sesuai direka untuk diletakkan di dalam tubuh manusia untuk aplikasi teleperubatan pada masa hadapan. Antena direka untuk beroperasi di Ultra-WideBand (UWB) untuk jarak dekat sistem komunikasi dalam perubatan dalam julat frekuensi 3.1GHz - 10.6GHz . Oleh itu, metamaterial ini telah direka di dalam antena menggunakan empat substrate (permukaan) yang berbeza dengan menggunakan Flame Retardant 4, Teflon, Alumina and PDMS sebagai substrate (permukaan). Antenna ini disimulasi dan dianalis mengunakan perisian Computer Simulation Technology (CST). Keputusan simulasi antenna dengan struktur metamaterial yang dicadangkan menunjukkan prestasi yang lebih baik seperti 'gain', 'directivity' dan nilai SAR. Berdasarkan keputusan empat substrate (permukaan) yang berbeza, Teflon menghasilkan keputusan yang lebih baik daripada substrate (permukaan) yang lain dalam ruang bebas dan dalam model lengan manusia. Nilai SAR berkurang daripada 5.68 W/Kg kepada 2.91 W/Kg menggunakan antena dengan struktur metamaterial. UWB antena dengan struktur metamaterial difabrikasi dan diuji di dalam makmal. FR4 digunakan sebagai substrate kerana had bahan, masa dan kos. Keputusan simulasi menunujukkan antena bersama metamaterial beroperasi pada 8.1GHz dengan -64.36 dB manakala dalam pengukuran ia beroperasi pada 8.5GHz dengan -25.72 dB. Kedua-dua hasil dari simulasi dan pengukuran menunjukkan bahawa antena dengan struktur metamaterial mempunyai prestasi yang lebih baik berbanding antena konvensional.

.

TABLE OF CONTENTS

II LITERATURE REVIEW

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

UWB	-	**Ultra-WideBand**
EM	-	**Electromagnetic**
DNG	-	**Double Negative Metamaterial**
SNG	-	**Single Negative Metamaterial**
NIM	-	**Negative Index Metamaterial**
CST	-	**Computer Simulation Technology**
RF	-	**Radio Frequency**
FCC	-	**Federal Communication Commission**
SRR	-	**Split Ring Resonator**
LHM	-	**Left-handed material**
VSWR	-	**Voltage Standing Wave Ratio**

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In medical technology, implantable antenna design for in-body application need to consider the unsafe effects of electromagnetic radiation towards human body. Hence there are many studies related to implantable antenna inside human body for this proposes. Designing implantable antenna is quite challenging because many parameters such as antenna size, low power requirements, biocompatibility with the body and high performance antenna are needed [1]. Researchers have begun to investigate and explored the performance of metamaterials in antenna. Designing metamaterial has become popular due to excellent accuracy, easy and affordable approach to antenna. Federal Communications Commission (FCC) approved Ultra-Wide Band (UWB) frequency in range 3.1GHz until 10.6GHz used band in medical implant communication. UWB has an ultra-wide frequency bandwidth and can achieve huge capacity as a high as hundreds of Mbps with distances of 1 to 10 meters. Thus, data can be transferred at higher rate and long distance.

1.2 Background Study

Metamaterials are artificially properties that does not ready exist in nature. One of the characteristics in metamaterial is that gain properties affect from their structures instead than chemical compositions. The concept of metamaterial discovering by Victor Veselago in late 1968, showed that materials with simultaneously negative permittivity ($\varepsilon < 0$) and permeability ($\mu < 0$) had slight difference compared to ordinary materials [2]. Metamaterials produce unusual electromagnetic properties such as negative magnetic permeability (μ), negative electrical permittivity (ε) and negative refraction index (n) across frequency range [2]. Material that has negative permeability and permittivity in the same frequency usually referred as left handed metamaterial (LHM) because the electric field, magnetic field and the wave vector are form a left handed system. He analyzed that the Poynting vector of the plane wave is anti-parallel to the direction of the phase velocity. As the result, metamaterial is a class of materials that allowed to manipulate permeability and permittivity which best suited for antenna designed.

1.3 Problem Statement

Antenna-enabled biotelemetry is gaining considerable attention in attempt to overcome the limitations of inductive biotelemetry related to low data rate and restricted communication range [3]. Lot of problems need to overcome in obtaining the ideal implantable device. The device must biocompatible to avoid unfavorable reactions in body [1]. Mostly, telemetry antenna designed before related to low data transfer and limited communication range. The suitable bio material antenna also needs to be design in order to avoid harm to human body during its whole applications inside the body. Metamaterial properties also produce negative refractive index and left handed material behavior which helps to enhance the gain and wider the bandwidth that lead to higher data rate transfer than conventional UWB antenna.

1.4 Project Objectives

Main objectives of this research are:

1. To design antenna with various bio-material build in metamaterial as the antenna substrate
2. To analyzed the suitability of various substrates on metamaterial antenna in order to achieve bio-compatible implant as well as having good attributes of antenna performance for in body application.
3. To verify the metamaterial antenna performance by measurement of its prototype antenna that able to operate on Ultra-Wide Band (UWB) frequency.

1.5 Scope of Work

The scope of work in this project is to designed a compatible antenna to be implant in human body. Microstrip is use as the patch for antenna. Microstrip is chosen because of their huge flexibility in design, conformability and easy to design in shape [3]. There are various bio-material as antenna substrate are used in this project such as Teflon, Alumina and PDMS because they are suitable to incorporate with human tissue [1][3]. The various substrates antenna is incorporated into a homogeneous human arm model. Unit cell of metamaterial is designed on substrate of those various substrates. The used of metamaterial is crucial in the design as it can manipulate the outcome of antenna performance by manipulating permittivity and permeability value when been used as the antenna substrate. Therefore, gain and bandwidth enhancement can be achieved. A negative permittivity can be obtained by ordered thin wires periodically. Split ring resonators (SRR) use to achieve negative permeability of structures. A patch and ground plate are made by cooper in designing the antenna. The coaxial feed is use as feeding line fetched in the middle of structure. The metamaterial will be implant on printed circuit boards. Antenna is design to be operating on Ultra-Wideband (UWB) for short range communication system in frequency of 8.1 GHz.

1.6 Chapter Review

This project is presented in five chapters. The thesis begins with an introduction to biocompatible antenna and metamaterial concepts. Chapter 2 is basically literature review about antenna, biocompatible antenna, UWB frequency, metamaterial antenna and antenna designed in details. Methodology, on how this project conducted and related flowchart was discussed more in chapter 3. Chapter 4 was focused on results obtained from the simulation process and significance discussion on appearance of the results. Chapter 5 was briefly stated conclusion for this project and future developments.

CHAPTER 2

LITERATURE REVIEW

The aim of this project is to design metamaterial antenna that are suitable for the UWB communication systems and implantable in human body. Concurrent to the design work, it is necessary to get familiar with some important parameters in antenna design. Important parameters that always have to be considered in antenna design are described. At the same time primary requirements for a suitable bio-compatible antenna are discussed. Some general approaches to achieve good metamaterial antenna design are presented. Also, some previous works related to UWB antenna and metamaterial design antenna configurations are introduced in this chapter.

2.1 Antenna Theory

Antenna is a medium that can transmit and receive signal from other applications such as microwave, radio, satellite and other suitable signal. An antenna act as a medium converting the electrical signal waves at certain operating frequency to electromagnetic waves in free space. Coaxial line or waveguide acts as transmission line to send electromagnetic energy to the receiver antenna [4]. In