DESIGN AND ANALYZE OF ULTRA-WIDEBAND ANTENNA FOR MEDICAL APPLICATIONS

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

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Supervisor Name : Prof. Dr. Zahriladha Bin Zakaria

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DEDICATION

To My Beloved Parents, Mohamed Alifuddin Bin Abu Bakar and Ani Zam Bt Latip.

To My Lovely Husband, Ahmad Faiq Bin Mohammad Ruslan.

To My Charlie Angels, Maifarah Nadzirah, Nur Anis Aqilah and Allis Afiqah.

ABSTRACT

"The goal of this thesis is to design compact printed the ultra-wideband antenna (UWB) at 3.1 GHz - 10.6 GHz. This thesis covers a basic study of microstrip patch antenna. In addition, to design and analyse Polydimethylsiloxane (PDMS) effects on UWB antenna design performance, which is a simulation-based study. Parametric studies also contain different technique studies to optimize different antenna parameters to obtain optimum results and performance. The combination of broadband bandwidth requirements and UWB system usage targets has led to increased interest in designing antennas for UWB applications as in medical applications. Antenna design and simulation are run using the CST Microwave Studio software. Recovering loss curves, bandwidth, antenna gain and radiation pattern results are shown for the designed antenna. Various results reflect the good antenna performance in UWB frequency. Then, the bandwidth obtained in the simulation is 804 MHz at 6.5 GHz while the bandwidth percentage is 123.7%. This UWB feature has been appreciated as key advantages for medical applications for good resolution. End of the results, the antenna at each transmitter and receiver have to be capable to function with UWB features to cater for this requirement.

ABSTRAK

Matlamat tesis ini adalah untuk mereka bentuk antena UWB yang dicetak pada 3.1 GHz - 10.6 GHz. Tesis ini merangkumi kajian asas 'microstrip patch' antenna. Di samping itu, untuk merangka dan menganalisis kesan Polydimethylsiloxane (PDMS) pada prestasi dalam mereka bentuk UWB antena, yang merupakan kajian berasaskan simulasi. Kajian parametrik juga mengandungi teknik yang berbeza untuk mengoptimumkan parameter antena yang berbeza untuk mendapatkan hasil dan prestasi yang optimum. Gabungan keperluan jalur lebar UWB dan sasaran penggunaan sistem UWB telah menyebabkan peningkatan dalam merancang antena untuk aplikasi UWB seperti dalam aplikasi perubatan. Reka bentuk dan simulasi antena dijalankan menggunakan perisian Studio CST Microwave. Kurva 'return loss', jalur lebar, keuntungan antena dan hasil corak radiasi ditunjukkan untuk antena yang telah direka. Pelbagai keputusan mencerminkan prestasi antena yang baik dalam frekuensi UWB. Kemudian, jalur lebar yang diperolehi dalam simulasi adalah 804 MHz pada 6.5 GHz manakala peratusan bandwidth adalah 123.7%. Ciri UWB ini telah dihargai sebagai kelebihan utama untuk aplikasi perubatan untuk penyelesaian resolusi yang baik. Akhirnya hasil antena pada setiap pemancar dan penerima harus mampu berfungsi dengan ciri UWB untuk memenuhi keperluan ini.

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LIST OF SYMBOLS AND ABBREVIATIONS

ANA	:	Agilent Network Analyser
BW	:	Bandwidth
CST	:	Computer Simulation Technology
dB	:	Decibel
EM	:	Electromagnetic
GHz	:	Gigahertz
MHz	:	Megahertz
mm	:	millimeter
MPA	:	Microstrip Patch Antenna
IEEE	:	Institute of Electrical and Electronics Engineers
IF	:	Infrared Frequency
LP	:	Linear Polarization
PDMS	:	Polydimethylsiloxane
RL	:	Return Loss
RO	:	Rogers
S11	:	Reflection Coefficient at port 1
UWB	:	Ultra-Wideband

CHAPTER 1

INTRODUCTION

1.1 Research Background

Ultra-wideband (UWB) (3.1-10.6 GHz) microwave imaging is one of the methods that used to detect the early stage of unusual tissue in the human body. The microwave imaging is widely used in the medical applications. There are many types of unusual tissues, such as the cancer tissue, tumor, rare muscle and etc. The antenna will received a signal whenever the unusual tissues passing through it. With the presence of the unusual tissue, more energy is reflected back and significantly affected the response to predict the location of the unusual tissues[1]. The hard and thick properties of material for low frequency substrate is not suitable for the printed antenna because it is not to follow the human body structure[2]. If the substrates is continued to bend, it can be crack[3]. This may causes lack of sensitivity in low performance of an antenna. The method that can use to make functioning the antenna is the active method which

is tomography and radar-base approaches. The research is focusing on medical applications. For example in tomography method, the radiation of single transmitter will be transfer into the tissue while a number of antennas will be placed around the any part of human body to receive any scattered wave[4]. This process will repeated for various position of transmitter.

This project is very safe for medical used as the antenna will not giving any negative effect to the human body as the antenna is use as a sensor for detection the unusual tissue and as a medium to transfer and received the signal. The antenna also can be used by anyone that is monitored by a doctor. This new type of antenna is experienced suitable to be applied for ultra-wide band. By doing so, it can assure the exact safeness when operating at high frequency used. It is very crucial to ensure the safety of the patient. In order to apply the idea and design, a material will be used as a substrate of antenna due to it has less stiff and good performance.

This project is very helpful for medical cause their performance in detecting the embedded in the human body. The propagation of ultra-wide band antenna which is operating at frequency 3.1 GHz till 10.6 GHz for medical applications with aim of bandwidth is more than 500MHz. The antenna is expected to exhibit the exact UWB response by using an alternative material which is adding Polydimethylsiloxane (PDMS).

1.2 Problem Statement

This project was determined to use the microstrip antenna and also called as printed antenna and the type of antenna is a patch antenna. Generally, the antenna has three layers where the first layer which is at the top is copper, the middle or the second layer is dielectric substrate material and the bottom layer is the ground plane.

Due to this project that need an antenna characteristic for medical application is the wideband frequency. The resolution of the reconstructed image is affected by the incident wave bandwidth and its center frequency[5]. An important antenna which can get a better performance for medical application such as in adding some insulator element on top of antenna to get more sensitivity and more resolution in detect unusual tissue around any part of human body by using high frequency material of substrate. Moreover, to have an accurate data in medical application, the antenna is required to be placed consistently from human body. The Figure1.1 shows an antenna placed on the human belly. To protect the antenna, and avoid direct contact with the skin, it was covered with a plastic bag in the measurement process[1]. In this project by adding an alternative material as a new improvement to cover the antenna from directly touch to the skin of human body is a good development.

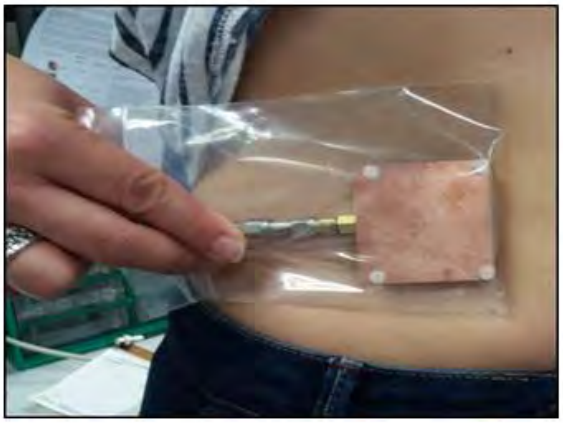

Figure 1.1: Antenna covered with plastic.

Besides, a medical system is envisioned to be lightweight, miniature in size, low profile, inexpensive, and easy to fabricate[6], [7]. The limitations of the antenna is to design the antenna in a suitable size which is can be fit use by human body which is not too big or smaller size. The microwave imaging technique that used also can be lack of sensitivity and functional in detection the unusual tissue.

1.3 Research Objective

i. To design compact printed ultra-wide band (UWB) antenna at 3.1 GHz-10.6 GHz.

ii. To design and analyze the Polydimethylsiloxane (PDMS) effect on performances of the UWB antenna design.

iii. To validate the design through experiment works in laboratory.

1.4 Scope of Work

i. An antenna is designed to achieve UWB frequency band which covers the entire 3.1 GHz – 10.6 GHz.

ii. A wide bandwidth antenna is designed by using a structure of microstrip antenna to obtain with more than 500 MHz

iii. The response of the antenna is validated through experimental work in the laboratory using Rogers RO4350B substrate material with 3.48 dielectric constant.

iv. Design and analyze with adding Polydimethylsiloxane (PDMS) in simulation and its permittivity is 2.7.

v. An alternative material which is adding Polydimethylsiloxane (PDMS) that it may improve the performance of antenna in simulation.

vi. Simulation using Computer Simulated Technology (CST) software, fabrication in laboratory using Rogers RO4350B and measurement using Agilent Network Analyzer (NA).

vii. Comparison between simulation results, measurement and then prove the concept through discussion and theoretical explanation in this project.

1.5 Motivation

My motivation leaning about wearable antennas is targeted through a future job, when I have gained more knowledge and experience besides this project. It is to fully utilize the usage of material properties such as PDMS on top of radiating element of antenna. The antenna will not giving any negative effect to the human body as the medium to transfer and received signal. Then, it is suitable to detect early stage of any unusual tissue such as tumor, cancer and others in hospitality requirement. The antenna can be used to anyone that is monitored by a doctor.

1.6 Thesis Organization

The thesis consists of five chapters which have been organized as follows:

Chapter 1 introduces the main concepts of the research, including definitions, problem statement, objectives, and scope of work and research contributions. The introduction of UWB applications, UWB antennas, Microstrip Antenna.

UWB technology, overview of type of antenna and review of recent of antenna are discussed in Chapter 2. This chapter describes the basic properties of antenna such as impedance, voltage standing wave ratio (VSWR), return loss, bandwidth, gain and directivity, UWB antennas characteristics are also discussed in this chapter. Moreover, UWB in medical application, monopole antenna and PDMS material also discussed in this chapter.

Chapter 3 provides the design methodology, including related equations, equivalent circuits, simulation process, and measurement procedures with other