ULTRA WIDE BAND ANTENNA ARRAY DESIGN AND DEVELOPMENT FOR MEDICAL APPLICATION

NABILA BINTI KAMARUDIN

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DR. IMRAN BIN MOHD IBRAHIM
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal

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Author : DR. IMRAN BIN MOHD IBRAHIM

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Special Dedicated:

To my beloved husband, my mother and in memories of my late father for the moral support, encouragement, guidance and motivation and also thanks to all my friends and colleagues throughout the completion of this report.

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ABSTRACT

This project is to design the antenna array for the use of ultra wide band frequency range spectrum. In the ultra wide band frequency, the microwave imaging has been used to detect the unusual tissues in the human body for example a tumor cell, cancer cell and other cells which uncompatible with normal tissue in human body. In addition, the microwave imaging also can provide an accurate detection and a good treatment with low cost for the early detection. The main thing about the microwave imaging technique is to observe microwave frequencies and conductivity between the normal and the malignant tissues. Therefore, an antenna was designed in an array design by using a suitable substrate in order to detect the unusual tissue in the human body. A substrate called Rogers RT/Duroid 5880 was used in this project as the thickness is just about 1.575mm which can easily flexible to all type of parts in the human body shapes. The antenna was designed by using a Computer Simulation Software (CST) to achieve a simulation result. The ultra wide band frequency for unusual tissue detection for microwave imaging is between the range of 3.1 GHz to 10.6 GHz. However, after done doing the simulation test, the result obtained was between the range of 3.5942 GHz until 8.1836 GHz with a bandwidth of 4.5894. While, for the two lowest return loss shows the simulation result of -17.594 and -16.724 with frequencies of 4.4750 GHz and 7.0565 GHz respectively. A lots of parameter sweep already done to make sure that the frequency of the antenna is between the bandwidth of the ultra wide band frequency range spectrum. Therefore, this antenna is practical used in the medical sector which helps the doctors and nurses applied this technology to the patients since the structure is flexible to all type of body shapes and the resulting frequency is still in the range of reading frequency microwave imaging

ABSTRAK

Projek ini adalah untuk mereka bentuk antena untuk penggunaan ultra lebar jalur frekuensi pelbagai spektrum. Frekuensi jalur lebar ultra, pengimejan gelombang mikro telah digunakan untuk mengesan tisu-tisu yang luar biasa di dalam tubuh manusia contohnya sel tumor, sel kanser dan sel-sel lain yang tidak serasi dengan tisu normal di dalam badan manusia. Di samping itu, pengimejan gelombang mikro juga boleh menyediakan pengesanan tepat dan rawatan yang baik dengan kos yang rendah bagi pengesanan awal. Perkara utama tentang teknik pengimejan gelombang mikro adalah untuk melihat frekuensi gelombang mikro dan konduksinya antara tisu sel biasa dan tisu malignan. Oleh itu, antena direka dalam reka bentuk yang mudah dengan menggunakan substrat yang sesuai untuk mengesan tisu yang luar biasa di dalam tubuh manusia. Substrat yang dikatakan adalah Rogers RT / Duroid 5880 telah digunakan dalam projek ini dengan ketebalan adalah hanya kira-kira 1.575mm yang mudah fleksibel untuk semua jenis bahagian-bahagian dalam bentuk tubuh manusia. Antena ini telah direka dengan menggunakan Computer Simulation Software (CST) untuk mencapai hasil simulasi. Kekerapan jalur lebar ultra untuk mengesan tisu luar biasa bagi pengimejan gelombang mikro adalah antara julat 3.1 GHz kepada 10.6 GHz. Walau bagaimanapun, setelah selesai menjalankan ujian simulasi, keputusan yang diperoleh adalah di antara julat 3.5942 GHz sehingga 8.1836 GHz dengan lebar jalur 4.5894. Manakala, untuk dua kehilangan kerugian berdasarkan hasil kajian yang paling rendah menunjukkan keputusan simulasi untuk -17.594 dan -16.724 dengan frekuensi 4.4750 GHz dan 7.0565 GHz masing-masing. Banyak parameter berkala sudah dilakukan untuk memastikan bahawa kekerapan antena adalah antara jalur lebar ultra lebar jalur frekuensi pelbagai spektrum. Oleh itu, antena ini praktikal digunakan dalam sektor perubatan yang membantu doktor dan jururawat menggunakan teknologi ini kepada pesakit kerana struktur yang fleksibel untuk semua jenis bentuk badan dan frekuensi yang terhasil masih di dalam julat bacaan frekuensi pengimejan gelombang mikro.

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LIST OF ABBREVIATIONS

Abbreviations	**Definition**
MI	Microwave Imaging
EM	Electromagnetics
PVC	Polyvinyl chloride
UWB	Ultra Wide Band
PCB	Printed Circuit Board
PC	Private Computer
WiHD	Wireless High Definition
LAN	Local Area Network
WAN	Wireless Area Network
MRI	Magnetic Resonance Imaging
CST	Computer Simulation Technology
1D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional

NOMECLATURE

Permittivity	The measurement of the resistance when there is an electric field in the medium
Conductivity	the measurement of the ability of the material which to produce an electric field or current

CHAPTER 1

INTRODUCTION

This chapter will explain about the antenna itself which introduce to this project, the objectives of the project, problem statement of the project and also discussed about the scope of work of the project.

1.1 Introduction

The basic component for electrical circuits is the antennas which provide the links for interconnecting between transmitters with the free space or between the free spaces with the receiver [1]. The antenna will convert the electrical power into the radio waves and vice versa [2]. There are six properties for antenna. First, the antenna gain which explained the measurement of the parameter for degree of directivity of radial pattern for antenna. The antenna was designed in the way which will rise in power for wanted direction and decreases for unwanted directions.

Secondly, is the aperture also known as the effective apertures that will actively participating in the transmission and reception in the electromagnetic waves. The collective area will associated with the power received by the antenna. Thirdly, the measurement of concentrated power radiation for a particular direction is defined for the

directivity of the antenna. For any given direction of the direct radiated power is one of the capabilities for the antenna.

Another part for choosing an antenna is the bandwidth that can be defined for the range of the frequencies over which antenna can radiates energy and also received energy. Fourth, is the polarization of the antenna that is launched by the electromagnetic waves and can be polarized vertically and polarized horizontally. If the polarization of the waves in the vertical direction, the vector of E will be in vertical condition and requires a vertical antenna while if the polarization of the waves in the horizontal direction, the vector of E will be in horizontal condition and requires a horizontal antenna. When using the circular polarization, both horizontal and vertical ways will be combined.

Fifth, will be the effective length which is the parameter of the antenna and was characterized the efficiency for the antenna in electromagnetic wave that include in transmitting and receiving. The effective length of the receiver is the electromagnetic ratio at the receiver input towards the intensity of the electric field that occurred on the antenna. The definition for the effective length of the transmitter can be conclude as the capacity of the free space in the conductor, and the distribution of the current generated with the same field intensity in any radiation direction across its length. Lastly is the polar diagram or called as radiation pattern with plot that explained about the antenna of its strength for the power field radiation. The plot can be obtained for vertical and horizontal plane and the plane also can be called as pattern [3].

There are five types of antenna that typically will be used which is Log Periodic Antenna (example Bow Tie Antenna, Log-Periodic Dipole Array), Wire Antenna (example Short Dipole Antenna, Dipole Antenna, Monopole Antenna, Loop Antenna), Travelling Wave Antennas (example Helical Antenna, Yagi-Uda Antenna), Microwave Antenna (example Rectangular Micro strip Antenna, Planar Inverted-F Antennas) and Reflector Antennas (example Corner Reflector, Parabolic Reflector) [3].

Nowadays, people were too busy doing work and they do not have enough time to take care about their self. Some people might not have any health sickness but some people need to be suffering for some disease. One of the main issues about health care is the unusual tissue that detected in the body for example a cancer tissue, tumor, rare

muscle and etc. The unusual tissue can be the great course of death and professional group of healthcare who struggle against the cancer were concerning the person who contract with the diseases. The increasing number of the disease is because of people who were lacking to be awareness about their health by regularly scanning their body.

In biomedical imaging, one of the main techniques used is the microwave imaging which is to detect the unusual tissue especially at the early stage and this project might focusing on the cancer tissue. The benefits of using this microwave imaging technique including the accessibility without effect harmful for tissue, real time monitoring, simple to perform, non-invasiveness, wide ranges and the costing is inexpensive if compared to the other techniques for example is the magnetic Resonance Imaging (MRI). This microwave imaging is widely use as monitoring the unusual tissue or cancer stages. This also helps to contribute the important information for planning the therapy and performance stages in detecting the unusual tissue or cancer tissue.

The microwave imaging (MI) that is used acts as a tool to screening and monitoring the unusual tissue. MI also has its own frequency that compatible for the unusual tissue to find the electrical properties, permittivity and conductivity between the normal and unusual tissue [4-6]. Other than that, the MI also can be used to monitor stoke. Therefore, MI helps in detection of the unusual tissue and as a tool to monitor treatment response since the unusual tissue can be detected at the early stage.

In this project, antenna array will be produce according to the task. Therefore, the meaning of the antenna array is the duplication of 2 more antennas. The antenna will produce a signal which will combine or processed according to improve the performance of the antenna [29]. There are some advantages when using the antenna arrays. First, the capability of the steerable beam can be provided by the array. The steerable beam here is referring to the changing of the radiation pattern. Secondly is the gain which is refer to the array gain is high when using the simple element of the antenna. For multipath signal reception for the diversity gain also can be provided by the antenna and the processing of the array signal can be enabling by the antenna [30]. There are some users of the antenna array that can help to increase the gain. The diversity reception also can be providing by the antenna array. For some particular set of direction, the antenna array can cancel out the interference. It also helps for the incoming signals by determine the

arrival direction. Finally, the antenna array can maximize the Signal to Interference Plus Noise Ratio (SINR) [29].

1.2 Problem Statement

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

Due to this project that need an antenna which can be bent according to the human body shape, the FR4 type of material for the substrate layer cannot be used because of the FR4 is very hard to be bended and causes difficulties to fit with the human body structure. Therefore a new material that is more flexible will be proposed.

The FR4 material also is not suitable for the printed antenna because it properties is less flexible to follow the human body structure. It has a weak edge structure that cannot be bended easily. If the FR4 is continued to bend, it can be crack [7]. The FR4 also is quite porous in nature compared with BT epoxy or polyimide.

Besides, the limitation of the antenna is to design the antenna in a suitable size which is can be fit and 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 Objectives

The objectives of developing of this project are listed as below:

1. To determine the materials used as a substrate for the antenna that can be bent according to the human body shape.
2. To design an antenna array with a suitable substrate that is satisfy the UWB frequency spectrum.

3. To achieve a simulation result of -10dB for ultra wide band frequency between 3GHz to 10GHz for array design.
4. To fabricate an antenna for ultra wide band frequency in array design

1.4 Scope of Project

There are a few specifications of scope being done in this project. In this thesis, there are two parts which is in part one, where the feasibility study regarding the responds comes from a stones as an unusual tissue inside the polyvinyl chloride (PVC) pipe as a hand of human body shape while the second part is covering about the quantitative microwave imaging in unusual tissue of human body by using the frequency of 3GHz to 10Ghz of ultra-wide band antenna.

The scope of this project is as following:

1. Designing technique of the antenna by using CST software.
2. Simulation the designed antenna by using CST software.
3. Research on type of substrate used for the antenna.
4. Suitable frequency of ultra-wide band antenna between 3GHz to 10GHz.
5. Fabrication process of the antenna
6. Testing the antenna functionality.

1.5 Thesis Structure

This thesis consist of five chapters organization structure which is each chapter will elaborate details about the topics involves in this report.

Chapter I describes about the general introduction of the antenna with the working of microwave imaging in medical use nowadays to detect the unusual tissues. The UWB antenna array also was explained in this chapter.

Chapter II explains about the history and some study of cases about the microwave imaging to detect the unusual tissues and the UWB frequency spectrum that

suitable used in this project. Then, the substrate used as the middle layer of the micro strip antenna that can be bent according to the human body shape was explained.

Chapter III is about the methodology of this project which is explain about the flow of the project and the requirement needed.

Chapter IV will present about the final output and the simulation about the antenna design by using CST software that can be run and result of the output will be explained in this chapter.

Chapter V will discusses about the conclusion and some suggestion for further recommendation on this project enhancement.

CHAPTER 2

LITERATURE REVIEW

In this chapter will explain about the type of the antenna with its substrate that will use which also leads to its functioning. Next, the information about the ultra wide band antenna array will be explained in this chapter which related also with the microwave imaging approaches that will detect the unusual tissue in the human body.

2.1 The Microstrip Patch

In this project, the micro strip patch antenna will be used. A micro strip or patch antenna means as the antenna which is fabricated by using micro strip technique on a printed circuit board (PCB) [8]. The board that will use also depending on the type of the substrate will be used and used at a microwave frequency. This type of antenna is a low profile antenna and has a flat surface and because of that, patch antenna sometimes called as planar antennas [9].

The basic form of patch antenna shows in Figure 1, a flat plate over a ground plane. As mention above, the antenna will printed on a PCB material and the substrate will makes up the dielectric of the patch antenna. The bandwidth of the antenna will determined by the distance between the patch antenna and the ground plane that