BEAM SWITCHING ULTRA-WIDEBAND ANTENNA FOR MEDICAL APPLICATION

LEE VEI HUNG

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunications Electronics) With Honours

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Tajuk Projek BEAM SWITCHING ULTRA-WIDEBAND ANTENNA FOR MEDICAL IMAGING

Sesi Pengajian 1 6 / 1 7

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(HURUF BESAR)

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DR. NOOR AZWAN BIN SHAIRI
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 2nd June 2017

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DECLARATION

I hereby, declare this report entitle "BEAM SWITCHING ULTRA-WIDEBAND ANTENNA FOR MEDICAL APPLICATION" is the results of my own research except as cited in the references.

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APPROVAL

"I hereby declare that I have read this report and in my opinion, this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honors"

Signature :

Supervisor's Name : DR. NOOR AZWAN BIN SHAIRI

Date : 2ND JUNE 2014

DEDICATION

Special dedication to my beloved parents,

Lee Keng Mun & Goh Sien Low

To my supervisors

Dr Noor Azwan Bin Shairi

Dr Imran Bin Mohd Ibrahim

My friends and my fellow lecturers

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

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ABSTRACT

Microwave imaging is an emerging technology in the medical sector which have similar function as X-ray, MRI, and CT scan. The operating frequency of microwave imaging is 3.1 GHz to 10.6 GHz which is also known as the Ultra-Wideband frequencies. The design of the microwave imaging system is using monostatic radar approach which antenna will be use as both transmitter and receiver, therefore a switching system that switch between transmitter, receiver, and 8 units of antenna sensors have to be design. The characteristics of the switching system need to have insertion loss lower than -6dB and isolation higher than -15dB. This switching system will be design using Advanced Design System (ADS) software and it contain one unit of Single Pole Double Throw (SPDT) and one unit of Single Pole Eight Throw (SP8T). Model of the capacitors, inductors, and PIN diode will be study and the performance is verify in this report whether it is suitable to operate in UWB frequency. Substrate use will be Roger RO 4350 with the dielectric constant of 3.48. The performance of the SPDT design and SP8T design will be review by the end of the report.

ABSTRAK

Pengimejan microwave merupakan teknologi baru dalam sector pengubatan dan dia mempunyai fungsi yang sama dengan system X-ray, MRI ataupun CT scan. Pengimejan microwave ini beroperasi pada frekuensi berjulat 3.1 GHz dan 10.6 GHz dan frekuensi ini dikenali sebagai *Ultra-Wideband* Frekuensi. Sistem pengimejan microwave yang ingin direka adalah berdasarkan radar yang berciri *monostatic approach* dimana satu antena akan berfungsi sebagai penghantar dan penerima frekuensi isyarat. Oleh itu, sistem penukaran antara alat penghantar, alat penerima dan juga 8 unit antena berfungsi sebagai alat pengesan hendaklah direka. Ciri-ciri untuk sistem ini adalah dengan kehilangan sisipan yang rendah daripada -6dB dan juga isolasi yang tinggi daripada -15dB. Sistem penukaran akan direka melalui *software Advanced Design System (ADS)* dan sistem tersebut mengandungi satu unit *Single Pole Double Throw (SPDT)* dan satu unit *Single Pole Eight Throw (SP8T)*. Modal komponent seperti kapasitor, induktor dan PIN diod akan ditentukan melalui projek ini dan adakah komponent-komponent tersebut sesuai diguna dalam operasi yang berfrekuensi UWB. Substrat papan litar yang akan diguna adalah modal Roger RO 4350 dengan nilai dieletrik 3.48. Prestasi SPDT dan SP8T yang dereka akan dipapar dalam repot ini.

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LIST OF ABBREVIATIONS

UWB	**-**	**Ultra-Wideband**
SPDT	**-**	**Single Pole Double Throw**
SP4T	**-**	**Single Pole Four Throw**
SP8T	**-**	**Single Pole Eight Throw**
ADS	**-**	**Advanced Design System**

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Overview of this project, objective and the scope of work of the project are discussed in this chapter. Problem statement is stated and it will overcome by objectives with appropriate methodology.

1.1 Project Overview

In biomedical sector, a screening system is a way of reading the abnormal tissue or health condition allocate inside a human body. The basic element in the biomedical scanning system are the signal emitted and different scanning system having different of emitting elements. For example, X-ray scanning system emit x-ray as the element to detect the unusual health condition in human body while magnetic resonance imaging scanning system emit magnetic field and pulses of radio wave as the detecting elements. In recent year, microwave frequency that range between 300 MHz to 300 GHz show its characteristics and capability in the field of scanning system. Ultra-wide band frequency which is the frequency range between 3.1 GHz to 10.6 GHz that located between the microwave frequency provide a better effect when come to the application of scanning system. As same as other scanning system, data are required to obtain from several point around the body under test, therefore an ultra-wide band beam switching unit are needed to introduce to switch between the antenna arrays. The switching unit have to ensure the power of signal from generator are reaching the antenna sufficiently which mean the loss introduce by the switching unit have to be as low as possible. Thus, a beam switching ultra-wide band antenna for medical application are introduce to overcome the problem.

1.2 Problem Statement

Medical Imaging acting as a crucial element in medical sector since the first discover of X-Ray by the year of 1895. There are several medical imaging system available currently such as X-ray, Computerized tomography scan (CT scan), magnetic resonance imaging (MRI) and others. All these system that mentioned project waves with different level of frequency and energy at particular aim in order to obtain data for the image construction. However, some of the wave such as X-ray are consider as high energy frequency which will cause cancer under a long term exposure. Besides, one of the concern about screening system available now is a bulky system which mean it is impossible to appear during first aid scene and failing in detect of bone crack during first aid might bring death to the casualty.

In past decade, researcher have been focus on using microwave frequency as the element of medical imaging especially used to map the tumor located in breast. Microwave frequency is low energy frequency which wouldn't ionize body atom or molecule that lowered the risk of getting cancer. It is believe with the application of microwave imaging technology in the biomedical sector, the problem with the existing screening system such as high implementation cost, bulky size, harming ionizing radiation and time consume could be overcome. There are several kinds of different studies regarding to microwave imaging technology that including types of microwave imaging approach, frequency range or even the shape of antenna arrangement. Types of approach such as monostatic radar approach and bi-static radar approach give different effect on the image construction under the affection of shape of antenna array as well. Therefore, it have to analyze which combination is the best suit for medical imaging purpose.

Beam switching system acting as a crucial element in microwave imaging system as in switching between antenna to get data from different point and angle are the focus point. By the purpose of fabricating a switching system for medical imaging purpose, the signal power that is suitable to be used have to be low enough that wouldn't bring any harm and the signal level are identified as 10dBm. Therefore, the insertion loss of the beam switching system have to be -3dB at the frequency of 3 GHz and -6dB at the frequency of 10 GHz. Besides the allow isolation of the system should be higher than -

15dB to prevent the stray signal flow into undesired path. The insertion loss have to be as low as possible in negative dB because this indicate that more or sufficient signal could be delivered out through the system and the isolation have to be as high as possible in the negative dB form to ensure the signal deliver through the desired path. If the isolation is low in negative dB, that will cause receiver receive the signal not only from one antenna but from more than one antenna and this will cause a distortion in the receiver output. Therefore, a topology of switch have to design in order to meet the requirement mentioned.

1.3 Objectives

The objectives of this project is to study and design a radio frequency switches that is small in size which is capable to become a portable switching system and also suitable for the ultra-wide band antenna with frequency range between 3.1 GHz to 10.6 GHz. Besides, the effect of different topology of the switching elements on switches have to be study and analyze as in it will affect the S-parameter such as insertion loss, return loss and isolation. The switching unit have to achieve insertion loss that higher than -3dB in 3 GHz and -6dB in 10.6 GHz together with isolation lower than -15dB in a broad bandwidth. Moreover, the beam switching method have to be identified for achieving fast switching between antenna arrays and able to produce good resolution of image.

1.4 Scope of Project

The scope of work for this project are:

1. The design of ultra-wide band bean switching unit that combine of SPDT switch back to back with SP8T switch with frequency range between 3.1 GHz to 10.6 GHz that have the S-parameter measurement of insertion loss less than 3dB and isolation less than 15dB.
2. The design of switch is simulated by using Advanced Design System (ADS) in order to study the effect of different topology of switches on S-parameters such as insertion loss, return loss, isolation and bandwidth.

3. Two switch are required to design in this project which is Single Pole Double Throw (SPDT) switches and Single Pole Eight Throw (SP8T) switches, once these two switches are simulated it is then observe with the insertion loss and the isolation performance of the switch.
4. The material of substrate used to design both SPDT and SP8T switch is by using ROGER RO 4530B epoxy board with dielectric constant of 3.47, tangent loss of substrate 0.037, thickness of substrate 0.508mm and thickness of copper is 0.0035mm.

1.5 Thesis Outline

Chapter 1 describes an introduction of the beam switching ultra-wide band antenna for medical imaging and the problem that faced by the society that could be overcome through developing this project. Besides, the objective and the scope of work for this project was set in order to achieve in the end of the project.

Chapter 2 describes the literature review on topology of microwave imaging system together with the scanning approach apply, ultra-wide band frequency, theory behind ultra-wide band antenna, comparison between RF switches and topology in designing RF switches.

Chapter 3 explains the methodology of the project with the use of flow chart. Then, step by step of development of the project will be discuss in details.

Chapter 4 include all the result mentioned in chapter 3 together along with the discussion on all the results.

Chapter 5 involve the conclusion of the overall project including the sustainable discussion, commercialization and also the future work of this particular project.

CHAPTER II

LITERATURE REVIEW

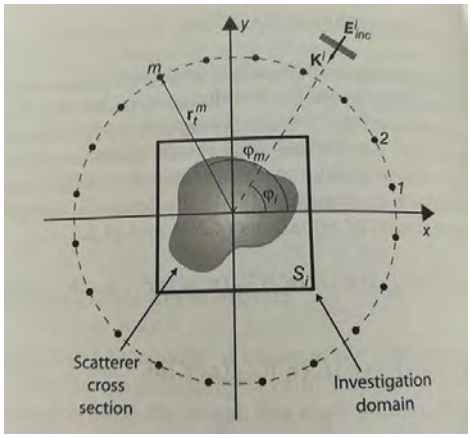
1.2

Microwave imaging is the application of microwave frequency that range between 300 MHz to 300 GHz, according to Matteo Pastorino microwave imaging technology is aim at sensing a given scene by the mean of microwave integration [24]. Microwave imaging has been widely apply in several sector such as civil and industrial application for the indestructible test and evaluation for example pipe leakage or crack in wall. Besides, microwave imaging technology is also applicable in shallow subsurface imaging which allow people to detect buried object and this is believed to be useful for military especially comes to demining activities.

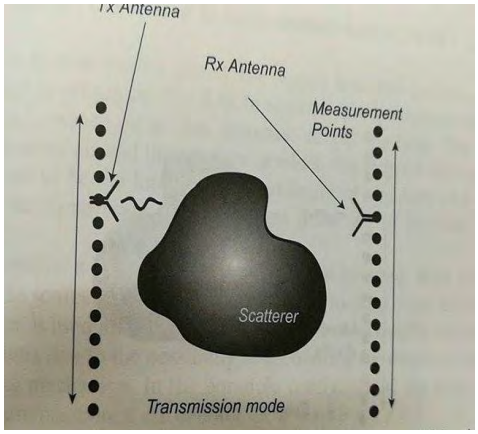
Starting the year of 1998, researchers been applying microwave imaging technology in the medical sector as a screening system [2]. Several studies about microwave imaging on health condition for brains and heart was carried out but the major focus of microwave imaging are in detecting tumor that located in the breast area [8-10, 12-14, 16, 20]. In order to build a microwave imaging system for screening purpose, several focus have to be made to utilize the technology for example scanning topology, frequency applies, how this technology works [3].

2.1 Microwave Imaging Topology in Medical Imaging

There are actually two different topology which can be involve for microwave imaging system in biomedical sector which is cylindrical (circular) and planar configuration which roughly with the idea shown below. [7]



(a)



(b)

Figure 2.1 (a) Circular and (b) Planar Scanning

Both topology shown above are the common topology used and a comparison between both topology is made. For the cylindrical topology, monostatic radar approach is applied while for the planar topology the bi-static radar approach is applied [1]. According to Microwave Engineering written by David M.Pozar monostatic radar approach is technology using one antenna act as both transmitter and receiver and the signal is analyze by interrogating the reflecting signal while bi-static radar approach having two different antenna act as transmitter and receiver and the signal analyze by mean of interrogating the back scatter signal from the target object [22].

Figure 2.2 shows comparison of both topology that have been done in year 2006. From that particular experiment, the material location are clearly determine through the