SWITCHING CIRCUIT DESIGN FOR LINEAR BI-STATICS ULTRA WIDEBAND (UWB) ANTENNA IN MICROWAVE BONE IMAGING APPLICATION

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Sesi Pengajian : 1 6 / 1 7

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"I hereby declare that the work in this project is my own except for summaries and quotation which have been duly acknowledged."

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Supervisor's Name : DR. NOOR AZWAN BIN SHAIRI

Date : 2/6/2017

DEDICATION

Special Dedicated to

My beloved family,

My main supervisor and co-supervisor

and all my friends

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ABSTRACT

This project is part of the microwave imaging system collaboration project. The microwave imaging system will utilize the Ultra Wideband (UWB) frequency band and aim to become a new alternative bone imaging system. This project only focus on one of the components in microwave imaging system, which is the switching circuit. A new switching circuit design is required because the switches available in the market are not suitable to be used in the microwave imaging system. The current switches have limitation of insufficient isolation, narrow operation bandwidth, or high cost. So, the objective of this project is to design a PIN diode Single Pole Four Throw (SP4T) switching circuit that have low insertion loss, high isolation over UWB frequency band. The project is carried out by first selecting suitable components, then determine switch topology with good performance and finally designing the SP4T switch through several design process. All the design is constructed and simulated in Advanced Design System (ADS) simulation software. The simulation results in each stage of the projects are documented in this thesis. From the final design, insertion loss lower than 5.53 dB and isolation higher than 13.748 dB is achieved. The insertion loss is within the desired design parameter but future improvement is needed to further increase the isolation of the switch.

ABSTRAK

Projek ini adalah sebahagian daripada project kolaborasi tentang sistem penimejan mikrogelombang. Sistem penimejan mikrogelombang ini akan menggunakan jalur frekuensi Ultra Wideband (UWB) dan bertuju untuk menjadi alternatif baru sebagai sistem penimejan tulang. Projek ini hanya fokus kepada salah satu komponen dalam sistem penimejan mikrogelombang tersebut, iaitu litar suis. Reka bentuk baru untuk litar suis adalah diperlukan sebab suis yang terdapat dalam pasaran tidak sesuai untuk digunakan dalam sistem penimejan mikrogelombang. Suis-suis dalam pasaran masa kini mempunyai limitasi tertentu, misalnya kekurangan dari segi isolasi, lebar jalur yang sempit atau harga produk yang tinggi. Oleh itu, objektif projek ini adalah untuk mencipta reka bentuk litar suis PIN diod jenis Single Pole Four Throw (SP4T). Reka bentuk tersebut perlu mencapai insertion loss yang rendah dan isolasi yang tinggi dalam jalur frekuensi UWB. Projek ini dijalankan melalui mencari komponents yang sesuai, kemudian memilih topologi suis yang berprestasi tinggi, dan akhirnya mereka bentuk suis SP4T dengan menjalani beberapa proces reka bentuk. Semua reka bentuk adalah dibina dan disimulasikan dalam perisian simulasi Advanced Design System (ADS). Keputusan simulasi bagi setiap tahap projek telah didokumentasikan dalam thesis ini. Daripada keputusan oleh reka bentuk terakhir, insertion loss kurang daripada 5.33 dB dan isolasi tinggi daripada 13.748 dB telah dicapai. Insertion loss tersebut adalah lebih baik daripada ekspektasi tetapi pengubah suaian dalam isolasi suis adalah diperlukan pada masa hadapan.

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ADS	-	Advanced Design System
CT scan	-	Computerized Tomography scan
DC	-	Direct Current
DGS	-	Defected Ground Structure
MRI	-	Magnetic Resonance Imaging
MTI	-	Microwave Tomographic Imaging
QUS	-	Quantitative Ultrasound
RF	-	Radio Frequency
SPST	-	Single Pole Single Throw
SPDT	-	Single Pole Double Throw
SP4T	-	Single Pole Four Throw
TSAR	-	Tissue Sensing Adaptive Radar
UWB	-	Ultra Wideband

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

An overview of the project is given followed by the problem statement, objectives, and scope of the project. A thesis outline is also given to give a brief idea on each Chapters in this thesis.

1.1 Project overview

This project is part of the collaboration project between Faculty of Electronic and Computer Engineering (FKEKK) of Universiti Teknikal Malaysia Melaka (UTeM) with KPJ Healthcare University College to conduct a research in medical imaging and image processing. The project collaboration agreement letter is attached in Appendix A. In medical bone imaging system, the main component are signal source, switching circuit, transmitter and receiver antenna, biasing voltage control, and computer for the data collection as well as data processing.

This project will focus on one of the components in the system, which is the switching circuit. PIN diode switch is chosen as the type of switching circuit because it have better switching speed for high frequency application. The role of the switching circuit is to provide ability to send the RF signal source to each of the transmitter antenna and also retrieve signal receive by each of the receiving antenna in a sequence controlled by the computer's bias voltage control circuit. The specification of the switching circuit used will has great impact on the overall performance of the imaging system. For this reason, this project is required to research and design a suitable switching circuit for the imaging system.

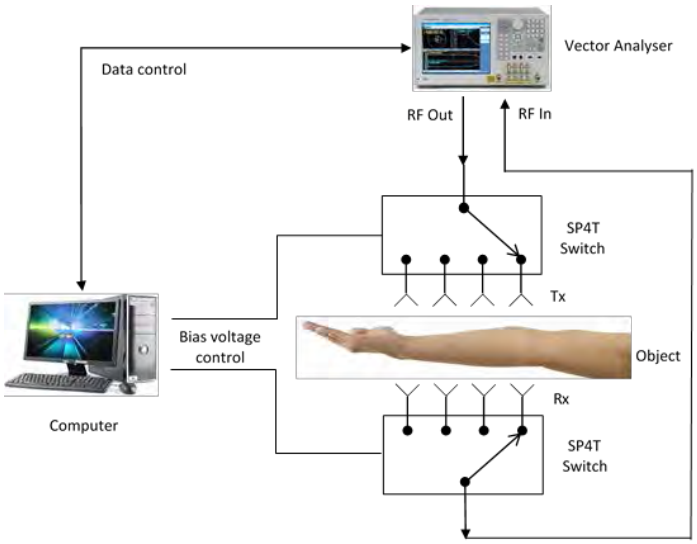

Figure 1.1: Block diagram of medical bone imaging system

1.2 Problem statement

Osteoporosis or bone related issue have been a great issue, especially among women. On average, for people at age 50 and above there is 1 in every 2 women and 1 in every 5 man suffer from osteoporosis. To counter with osteoporosis and some other bone related diseases, bone monitoring system play a very important role as it is required for disease prevention, detection and treatment analysis. Currently, the commonly used bone scanning system are X-ray, Computerized tomography (CT) scan, and Magnetic Resonance Imaging (MRI). These old scanning technology have some disadvantages such as high production cost, bulky size of the machine and ionizing radiation effect that may threaten the health of body cells.

Microwave frequency signal was suggested as the alternative to ionizing radiation used in X-ray and CT scan. However, the application of microwave frequency in medical imaging field is still required a lot of improvement so that the imaging ability is on par or even better than current technology. From several research done, it shows that to improve the imaging resolution, the system is required to work in larger signal bandwidth. At the same time, to acquire accurate raw data for processing, the intra-system interference should be keep lower. To ensure good performance of the whole system, the switching circuit must have suitable parameter so that it will not degrade the imaging performance. However, it is a great challenge

to maintain low insertion loss and high isolation at the same time over a wide operating frequency bandwidth.

1.3 Objectives

The purpose of doing this project is to select suitable diode topology and then design a Single Pole Four Throw (SP4T) switching circuit using the selected diode topology. The SP4T switch should have low insertion loss, high isolation and operates at large frequency band in order to support the microwave bone imaging system.

1.4 Scope of project

The scope of this project are:

i. Comparison and selection of suitable components that can works in the desired frequency range.
ii. Selection of suitable diode topology to be used in switching circuit design.
iii. Single pole four throw (SP4T) PIN diode switch design.

The design and simulation is done using Advance Design System (ADS) software. This software helps in simulates and analyse the design to make sure the desired parameter of the switches are obtained. The substrate used is Rogers RO4350B. The design parameters of the switch is set as the value in Table 1.1.

Table 1.1: Design parameters of SP4T switch

Parameters	Value
Operation frequency	UWB (3 GHz – 10 GHz)
Insertion loss	< 6 dB
Isolation	> 15 dB

1.5 Thesis outline

Chapter 1 introduces the information about the project.

Chapter 2 reviews all related study done by other researcher and some background information about the current medical imaging technology.

Chapter 3 explains the process and how the project is carried out.

Chapter 4 contains all the results obtained through each stage of the project and discussion about the results.

Chapter 5 conclude the work done in this thesis and suggestion on the future work.

CHAPTER 2

LITERATURE REVIEW

This chapter includes review of background, previous study or previous researches done on similar system, and also related theory which contributes a lot for better understanding, throughout this project.

2.1 Development of microwave imaging

Before the microwave imaging being applied in the field of bone imaging, this type of technique have already being developed for other application. One of the most related application filed is breast cancer detects scanning system, which is also human medication field. In the breast cancer detection system, a few type of microwave imaging system have been developed. Some example of the successful breast imaging system are Tissue Sensing Adaptive Radar (TSAR) [1] and microwave tomographic imaging (MTI) [2] techniques. The detection of breast cancer tissues is based on the electrical property (permittivity and conductivity) differences between normal cells and tumour cells [3]. With the aid of knowledge on signal scattering, when the transmitted signal hit the tumour tissues and the scattered signals received by multiple antennas from different direction, the confocal method by delay and sum algorithms can be used for the breast image reconstruction [4].

2.2 Potential of microwave imaging in bone imaging

Before the microwave imaging can be applied in bone scanning field, the feasibility of this technology must be proven first. Many researcher have contributed in proving the potential of bone imaging using microwave system. In [5], MTI system developed in [2] for breast cancer detection was used in its experiment to perform

imaging on the heels of injured patients to test the potential of MTI system. The imaged constructed was then compared to other scanning system such as MRI, CT scan, and Quantitative ultrasound (QUS).

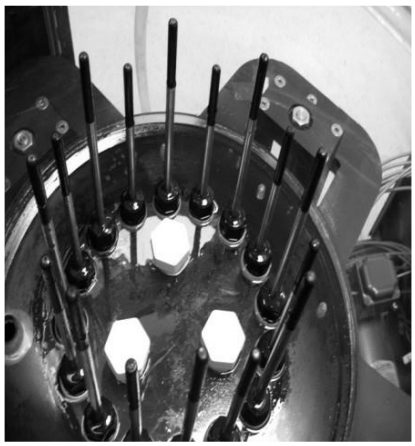

Figure 2.1: MTI system with 16 monopole antennas positioned in circular array

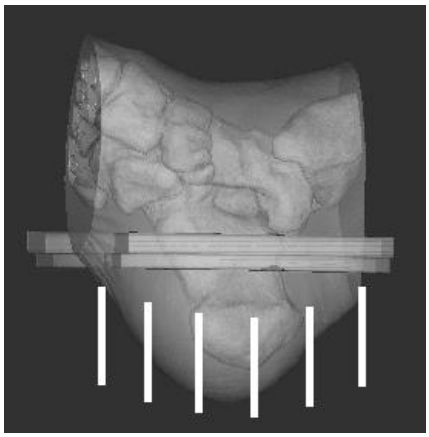

Figure 2.2: Illustration of MTI scan on human heel

The result of the experiment is very convincing because the heel image constructed using MTI system is able to convey meaningful information about the heel structure and property distribution. Furthermore, according to the author, better image is still possible by increasing the frequency of the signal used in scanning and constructing 3D image using stacking of 2D images.