PERFORMANCE ANALYSIS OF MICROWAVE IMAGING SYSTEM FOR DIFFERENT MICROWAVE SENSORS

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

Firstly, I would like to express my humblest gratitude towards Allah SWT for His Blessing and guidance. Next, I would like to dedicate my thesis to my beloved family. Their endless love, encouragement and support are the most important things occurred in my life. Furthermore, I would like to dedicate this work to my beloved project supervisor, Prof. Madya Dr. Mohamad Zoinol Abidin Bin Abdul Aziz. He had given me a lot of guidance, encouragement, assistance and always supporting me through completing this project. Finally, I would like to dedicate my thesis to all my lecturers and my fellow friends who always gives me support and guidance in any situation.

ABSTRACT

Detection system such as imaging system are widely used today in variety of means. There are imaging systems for medical treatment, to detect defects in a structure and to locate or detect object that has been obstructed by a certain structure. Although microwave imaging has the potential to improve sensitivity and accuracy, several challenges and limitations concerning the system still exist. The aim of this project is to design and develop different types of sensors for the system and to analyze the performance of the sensor based on the sensitivity of the sensors. The sensors that were studied in this project are microwave sensors and three different sensors were designed by using antenna design technique. After the sensors were designed, basic measurement of the sensors was taken, and the sensors were implemented into a microwave imaging system. The simulation and measurement results showed a good agreement in terms of return loss, gain and polarization.

ABSTRAK

Sistem pengesanan seperti sistem pengimejan digunakan secara meluas pada hari ini dalam pelbagai cara. Terdapat sistem pengimejan untuk rawatan perubatan, untuk mengesan kecacatan dalam struktur dan juga untuk mencari atau mengesan objek yang telah dihalang oleh struktur tertentu. Walaupun pengimejan gelombang mikro mempunyai potensi untuk meningkatkan sensitiviti dan ketepatan, beberapa cabaran dan batasan yang berkaitan dengan sistem ini masih wujud. Tujuan projek ini adalah untuk mereka bentuk dan membangunkan pelbagai jenis sensor untuk sistem dan menganalisis prestasi sensor berdasarkan sensitiviti sensor. Sensor yang dikaji dalam projek ini adalah sensor gelombang mikro dan tiga sensor yang berbeza telah direka dengan menggunakan teknik reka bentuk antena. Selepas sensor direka, pengukuran asas sensor telah diambil, dan sensor telah dilaksanakan ke dalam sistem pengimejan gelombang mikro. Hasil simulasi dan pengukuran menunjukkan persetujuan yang baik dari segi kerugian pulangan, gandaan dan polarisasi

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LIST OF SYMBOLS AND ABBREVIATIONS

FR-4	:	Flame Retardant 4
GPR	:	Ground Penetrating Radar
EM	:	Electromagnetic
RF	:	Radio Frequency
MRI	:	Magnetic Resonance Imaging
GHz	:	Gigahertz
MHz	:	Megahertz
CST	:	Computer Simulation Technology
RCS	:	Radar Cross Section
NDT&E	:	Non-Destructive Test & Evaluation
CT	:	Computed Tomography
RL	:	Return Loss
λo	:	Wavelength of radio waves
εr	:	Dielectric Constant
$\varepsilon reff$	:	Effective dielectric constant
d	:	Depth resolution
c	:	Speed of light
Zo	:	Charactristic Impedance

fc	:	Resonance frequency
mm	:	millimeter
dB	:	decibel
m	:	meter
BW	:	Bandwidth
$S11$	:	Reflection Coefficient
SMA	:	Surface Mount Adapter
UWB	:	Ultra-wideband
DGS	:	Defected ground structure

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Recent years have shown a dominant interest in ultra-wideband (UWB) microwave radar-based imaging technique. The advances in UWB systems and applications are progressing rapidly. Microwave Ultra-Wide Band imaging is currently a very promising technology for wireless communications son very high speed, high precision radars and imaging systems [1]. This project will focus on designing microwave sensors by using antenna design technique for implementation on imaging systems in order to locate or detect objects behind barriers and obstacles.

Antenna is an important part in an imaging system which it converts the electronic signals to electromagnetic. It is an electromagnetic radiator, sensor, transducer and impedance matching device that can be used extensively in all communication, radar and bio-medical systems. As a transducer, the antenna converts radio frequency (RF) electrical current into an electromagnetic (EM) wave of the same frequency.

1.2 Project Objectives

For this project, the objectives are to design and develop different design of microwave sensors based on antenna design technique for the microwave imaging system. This project will also study and analyze the performance of the sensors based on the parameters of antenna such as gain and antenna polarization; linear polarization, and circular polarization in microwave imaging system that operates in resonant frequency of 2.4 GHz

1.3 Problem Statement

Nowadays, there are various types of detection system exists such as imaging system for medical treatments in hospitals. In this context, imaging system will be emphasized where there are some cases that imaging system act as an essential tool not only for medical applications, but to solve problems like when an earthquake occurs, imaging system can be used to detect victims that are trapped under rubbles. Imaging system implements a transmission of radio waves. The reflection of the waves will be received, and the information is used to generate data. For an imaging radar, the returning waves are used to create an image. When the radio waves reflect off objects, this will make some changes in the radio waves and can provide data about

the objects, including how far the waves traveled and what kind of objects they encountered.

In this case, microwave imaging is the preferred solution rather than system such as X-ray imaging, Ultrasound, or Magnetic Resonance Imaging (MRI). This is because microwaves can penetrate through obstacles with ease because of its properties with wavelength ranging from one meter to one millimetre and possess frequencies between 300 MHz and 300 GHz. Microwave imaging is a low-cost system, with the usage of safer nonionizing radiation, the ability to image bulk-electrical tissue properties, and the ability to provide functional imaging without using contrast agents are the advantages of microwave imaging system.

Although microwave imaging has the potential to improve sensitivity and accuracy, several challenges and limitations concerning the system still exist. Through the imaging system hardware point-of-view, microwave imaging systems might require suitable microwave sensors for signal transmission and data collection. This mean that the sensitivity of the system contributes to the limitations of the system. The sensors play a major role for the sensitivity of the system. This is because, through microwave imaging system, any changes on the waves that propagates from the transmitter through the sample and back to the receiver will be detected based on the sensitivity of the sensors.

Different properties of objects such as the density, weight and type of materials will show different changes on the waves. The changes can be an issue to the sensors because each sensor have their own limitations such as did not have higher penetrating power. This project aims to design and develop different types of microwave sensor

based on antenna design technique for the microwave imaging system and to analyse the performance of each sensors on the microwave imaging system according to their sensitivity.

1.4 Scope of Project

In order to achieve the objective of the project, several scopes need to be identified. The scopes of this project are:

i. Three different microwave sensors are designed based on antenna design technique for the microwave imaging system.
ii. All the designed microwave sensors are simulated by using the CST (Computer Simulation Technology) Studio Suite 2017.
iii. Designed sensors are fabricated using lab equipment and measurements of antenna parameters are also being done in the lab. The parameters that are being investigated are the gain of antenna, polarization effect and the radiation pattern of the antenna.
iv. The microwave imaging system is developed in experimental scale and all the designed microwave sensors are implemented into an existing system.
v. The microwave imaging system will be measured alongside all the different sensors based on the antenna parameters and the performance of the system is based on the antenna reflections on targeted object and the Radar Cross Section (RCS).