DEVELOPMENT OF MICROWAVE IMAGING SYSTEM USING MULTI-STATIC CONFIGURATION WITH POLARIZATION DIVERSITY FOR OBJECT DETECTION

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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

My humble effort is dedicated to God the Almighty for bestowing upon me my sweet and loving parents, CHANDRAN A/L GANAPTHY and VANAJA A/P SUBRAMANIAM, siblings, and loved ones, whose affection, love, patience, encouragement, and day and night prayers have enabled me to achieve such success and honour. Thankful.

ABSTRACT

Imaging systems, for example, play an essential role in our daily lives. It has been widely employed in a variety of applications, including civil, industrial, and biological, to identify or detect an object that has been obscured by a structure. X-rays, CT scans, MRI (magnetic resonance imaging), ultrasound, and microwave imaging are just a few examples of imaging. In order to detect the substance, the sensors of the 4x4 MWI system based on a multi-static arrangement have been designed. The microwave sensors with different polarization angles of 0 degrees, 45 degrees, -45 degrees, and 90 degrees have been designed using a rectangular patch structure at a frequency of 2.4GHz. All sensors are able to meet the minimum criterion of -10dB for the reflection coefficient. The next step was to configure the 4x4 multi-static MWI system so that it could be tested for object detection. This setup consists of four transmitter (Tx1 – Tx4) and four receivers (Rx 1 – Rx 4) and all the signal transmitted simultaneously to each four receivers. During this time, several materials, including an empty bottle, water, soap, stones, oil, and flour, were chosen to be examined (MUT). The receivers are connected to AD8318 module to convert AC to DC signal which the operating frequency is 1 to 8GHz with input power between 5dBm to -65dBm, supply voltage of 7V to 15V and producing the output voltage in range of 0V to 2V. This project is using Arduino MEGA 2560 as the processing unit and for the display module, this system is using the 3.5” TFT screen display. The development system is able to characterize the different material based on the detected voltage.

ABSTRAK

Sistem pengimejan, sebagai contoh, memainkan peranan penting dalam kehidupan seharian kita. Ia telah digunakan secara meluas dalam pelbagai aplikasi, termasuk sivil, perindustrian dan biologi, untuk mengenal pasti atau mengesan objek yang telah dikaburkan oleh struktur. X-ray, imbasan CT, MRI (pengimejan resonans magnetik), ultrasound, dan pengimejan gelombang mikro hanyalah beberapa contoh pengimejan. Bagi mengesan bahan tersebut, penderia sistem 4x4 MWI berdasarkan susunan berbilang statik telah direka bentuk. Penderia gelombang mikro dengan sudut 0 darjah, 45 darjah, -45 darjah dan 90 darjah telah direka dan dihasilkan menggunakan struktur tampalan segi empat tepat pada frekuensi 2.4 gigahertz. Semua penderia dapat memenuhi kriteria minimum -10dB untuk pekali pantulan. Langkah seterusnya adalah untuk mengkonfigurasi sistem MWI berbilang statik 4x4 supaya ia boleh diuji untuk pengesanan objek. Pada masa ini, beberapa bahan, termasuk botol kosong, air, sabun, batu, minyak, dan tepung, telah dipilih untuk diperiksa (MUT). Penerima disambungkan ke modul AD8318 untuk menukar AC kepada isyarat DC yang frekuensi operasi adalah 1 hingga 8GHz dengan kuasa input antara 5dBm hingga -65dBm, membekalkan voltan 7V hingga 15V dan menghasilkan voltan keluaran dalam julat 0V hingga 2V. Projek ini menggunakan Arduino MEGA 2560 sebagai unit pemprosesan dan untuk modul paparan, sistem ini menggunakan paparan skrin TFT 3.5".

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

MWI : Microwave Imaging

RF : Radio Frequency

MRI : Magnetic Resonance Imaging

CT : Computed Tomography

CST : Computer Simulation Technology

SUT : Subject Under Test

MUT : Material Under Test

SIMO : Single Output Multiple Output

MISO : Multiple Input Single Output

MIMO : Multiple Input Multiple Output

ADS : Advanced Design System

AVA : Antipodal Vivaldi Antenna

UV : Ultra Violet

TFT : Thin Film Transmitter

FR : Flame Retardant

UWB : Ultra Wideband

GHz : Gigahertz

dB : Decibel

MAVA : Modified Antipodal Vivaldi Antenna

mm : millimeter

VNA : Vector Network Analyzer

PC : Personal Computer

SNR : Signal-to-Noise Ratio

FDTD : Finite Difference Time Domain

FFT : Fast Fourier Transform

SAR : Synthetic Aperture Radar

ADC : Analog-to-Digital Converter

SMA : Sub Miniature Version A

L : Length of the substrate

W : Width of the substrate

di : Diameter

TL : Feeding Line gap

LIST OF APPENDICES

CHAPTER 1:

INTRODUCTION

1.1 Background

In around the turn of the twentieth century, the first wireless revolution occurred, resulting in widespread mobile communications. Since then, the cost and size of microwave and millimetre-wave circuits have decreased dramatically, as has the emergence of single-chip radars that operate well into the 70 GHz bands. As a result, imaging and diagnostics applications have grown rapidly. As a result, image has become increasingly important in today's environment.

There has been a boom in interest in creating microwave imaging systems for a range of applications in recent years, including civil, industrial, and biomedical

applications. Microwaves, in fact, could permeate dielectric materials, allowing them to obtain information about the samples' interior dielectric properties almost instantly.

Despite the potential benefits, there are still certain difficulties that need to be addressed, which is why more research is being done in this area. In a Microwave Imaging System, the antenna acts as both a transmitter and a receiver. The sending antenna sends microwave signals through the hidden object, while the receiving antenna picks up scattered signals. According to recent research using the antenna as a sensor in a MIS, the antenna should have the following characteristics: high gain and small size; directed power radiation; the ability to transmit a wide range of frequencies with greater efficiency; model simplicity; and the ability to operate at both low and high frequencies.

The limits of present detection techniques are discussed in this thesis, as well as proposed microwave sensor imaging approaches and basic antenna characteristics. We also go through the antenna sensor that will be developed for Microwave Imaging systems as part of this project. The antenna covered a frequency range of 3 to 8 GHz. The antenna sensor will be built, and the reflection coefficient, radiation pattern, gain, and directivity of the proposed antenna will be compared to the measured and simulated findings.

1.2 Project Introduction

Microwave imaging, often known as MWI, is a type of imaging technique that makes use of electromagnetic radiation in order to detect or find things that are buried