DESIGN OF RF-CODES SENSOR FOR MICROWAVE IMAGING SYSTEM

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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

To my beloved mother, father and all my family members

My supervisor

And all my friends

For their love, encouragements, and best wish

ABSTRACT

Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are two classic imaging equipment used in diagnostic techniques. However, these imaging technologies have several drawbacks, such as being quite expensive and not always available in many medical centres and other industries. Furthermore, these devices are bulky and have limited mobility. In addition, conventional CT scanners cannot be used regularly on the human body since the scanner exposes people to higher ionization radiation. The constraints of the equipment necessitate the development of an alternate imaging technology that is inexpensive in cost, compact in size, movable, and non-ionizing. Microwave imaging equipment costs a fraction of other imaging techniques, making it a cost-effective technology. In addition, it is non-ionization radiation imaging technology. At the same time, microwave imaging systems need a more complex and powerful processing unit due to monostatic and bistatic configurations that need to rotate at every angle to cover all the area. This project aims to design four sensors based on wideband sensor techniques with notch frequencies characteristic for conventional multi-static microwave imaging to overcome all these limitations. The notch frequencies were developed by using multiple slots. All sensors are capable of generating RF codes signals at notch frequencies. These sensors work with 10 GHz bandwidth, which can be applied in microwave imaging applications.

ABSTRAK

Computed Tomography (CT) dan Magnetic Resonance Imaging (MRI) ialah dua peralatan pengimejan klasik yang digunakan dalam teknik diagnostik. Walau bagaimanapun, teknologi pengimejan ini mempunyai beberapa kelemahan, seperti agak mahal dan tidak selalu tersedia di banyak pusat perubatan dan industri lain. Tambahan pula, peranti ini besar dan mempunyai mobiliti terhad. Di samping itu, pengimbas CT konvensional tidak boleh digunakan secara tetap pada tubuh manusia kerana pengimbas mendedahkan orang kepada sinaran pengionan yang lebih tinggi. Kekangan peralatan memerlukan pembangunan teknologi pengimejan alternatif yang murah dari segi kos, saiz yang padat, boleh alih dan tidak mengion. Peralatan pengimejan gelombang mikro menelan kos sebahagian kecil daripada teknik pengimejan lain, menjadikannya teknologi yang kos efektif. Di samping itu, ia adalah teknologi pengimejan sinaran bukan pengionan. Pada masa yang sama, sistem pengimejan gelombang mikro memerlukan unit pemprosesan yang lebih kompleks dan berkuasa kerana konfigurasi monostatik dan bistatik yang perlu berputar pada setiap sudut untuk meliputi semua kawasan. Projek ini bertujuan untuk mereka bentuk empat penderia berdasarkan teknik penderia jalur lebar dengan ciri frekuensi takuk untuk pengimejan gelombang mikro berbilang statik konvensional untuk mengatasi

semua batasan ini. Frekuensi takuk telah dibangunkan dengan menggunakan berbilang slot. Semua sensor mampu menjana isyarat kod RF pada frekuensi takuk. Penderia ini berfungsi dengan lebar jalur 10 GHz, yang boleh digunakan dalam aplikasi pengimejan gelombang mikro.

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LIST OF SYMBOLS AND ABBREVIATIONS

AUT	Antenna Under Test
CST	Computer Simulation Technology
dB	Decibel
GHz	Gigahertz
RL	Return Loss
VSWR	Voltage Standing Wave Ratio
MI	Microwave Imaging
BW	Bandwidth
VNA	Vector Network Analyzer
DP	Dielectric properties
GPR	Ground penetrating radar
RCS	Radar Cross Section

CHAPTER 1

INTRODUCTION

This chapter provides an introduction to the project. First, motivation is being introduced. Then, the problem statement and objective of this project are described. The research scope and thesis outline are highlighted at the end of this chapter.

1.1 Background

According to the National Cancer Institute, brain cancer claimed the lives of 4.4 percent of the population in 2012. Based on data trends since 1990, In 2015, this figure is predicted to increase by 33.3 percent. Diagnostic equipment such as Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans are commonly used for diagnostic operations, however they are not uniformly available in all medical centres. This is due to its most serious issue, which is its exorbitant price. As a result of the high diagnostic cost, the diagnosis and detection procedure may be delayed. As a result, a lower-cost alternative device that can be used for diagnostic purposes is required [1].

Larsen and Jacobi conducted the first tests using microwaves as a medical imaging modality in the 1970s, when they conducted a detailed investigation on imaging a dog kidney using microwave radiation [2][3][4]. They were able to image a dog kidney in 2D in both the frequency and time domain. In both situations, there was a lot of variation in the data collected among various tissues. As a result of Larsen and Jacobi's research, microwaves immediately became the focus of imaging applications. Microwave imaging research highlighted many of the obstacles in near-field imaging of biological tissues early on. Microwaves are complicated by their nature and how they interact with live tissues. Microwaves as an imaging application drew a lot of attention in the 1970s and 1980s, thanks to radiometry, microwave acoustic systems, and microwave imaging.

Microwave imaging can be a low-cost alternative to obtaining a body image. Microwave imaging is a technology that detects the presence of an anomaly or object embedded in the scanning area by comparing the dielectric properties (DP) of an object to its surroundings. Because of the dielectric characteristics contrast, scattering signals will be produced, indicating the presence of an object and its location. Because the study of scattered signals can be utilised to detect an object, typical communication equipment such as a vector network analyzer (VNA) can be employed for the characterization and analysis of these signals. As a result, compared to CT and MRI, the Microwave imaging approach is relatively inexpensive [5].

A microwave imaging system, often known as a microwave camera, typically consists of a transmitter (typically an antenna) that transmits microwave signals to illuminate the studied structure. Some of these signals will transit through a structure with their phase and amplitude changed on the other side, while others will reflect depending on the parameters of the scanned layer of the system with changes in magnitude and phase. A sensor after that can be used to detect these changing signals. This sensor's location is determined by the imaging technology used (reflection or transmission through).

Furthermore, Microwave imaging has several advantages when it comes to detecting tumours in the breast or the brain. Microwave imaging that uses non-ionizing radiation has no adverse health consequences for human tissues. Because Microwave imaging detects tumours based on dielectric contrast, it has a good chance of detecting and diagnosing cancer at an early stage. Furthermore, when it comes to breast cancer detection, Microwave imaging is more comfortable for the patient than breast compression during the mammography process. Although there are no design frequency limitations for Microwave imaging antennas, narrow bandwidth (BW) antennas yield lower image quality than broad BW antennas, as described in [3]. As a result, the higher the antenna BW, the higher the quality of the resulting image, also known as image resolution. This project will concentrate on designing a suitable RF codes sensor to generate RF code signals for microwave imaging systems. As a result, the motivation for this research investigation is highlighted in the next section [5][6][7].

1.2 Problem Statement

Recent events have demonstrated the need for systems qualified for detecting hidden objects. A wide variety of techniques is already available for the scanning system. It has been used widely in various applications, including civil, industrial, and medical imaging. In general, it has been long used for visualizing the interior of the human body and is considered an essential tool for diagnosing and identifying abnormalities such as cancer diagnosis. Furthermore, the detection system may be utilised to detect many risks, including weapons, explosives, and illicit objects, such as drugs or illegal immigration. In addition, it can be used in security systems. Many different techniques can be used in detection systems, such as MRI (magnetic resonance imaging), ultrasound, X-rays, CT (computed tomography) scans, and microwave imaging. To create an image, each imaging technique employs a different technology. The use of these procedures regularly, however, raises health risks since they employ ionizing radiation, which can harm healthy tissues. Furthermore, there is a high cost when using these techniques because they use colossal equipment setup and require a long time for scanning.

New detection technologies such as microwave imaging systems can play an essential role in handling these problems. Microwave imaging is suitable for a detection system because of its non-ionizing, non-dissociation, portability, real-time imaging, and lower cost. However, a microwave imaging system needs more processing power tools capable of analyzing and presenting the information in terms of imaging for monostatic and bistatic configuration systems. Hence, it needs a more complex and powerful processing unit. Therefore, this project is linked to designing a suitable RF codes sensor for multistatic MWI in a coding transmission system to generate RF codes signals that immediately give information about the hidden object to overcome all these limitations of the unit processing in the multistatic microwave imaging applications.