



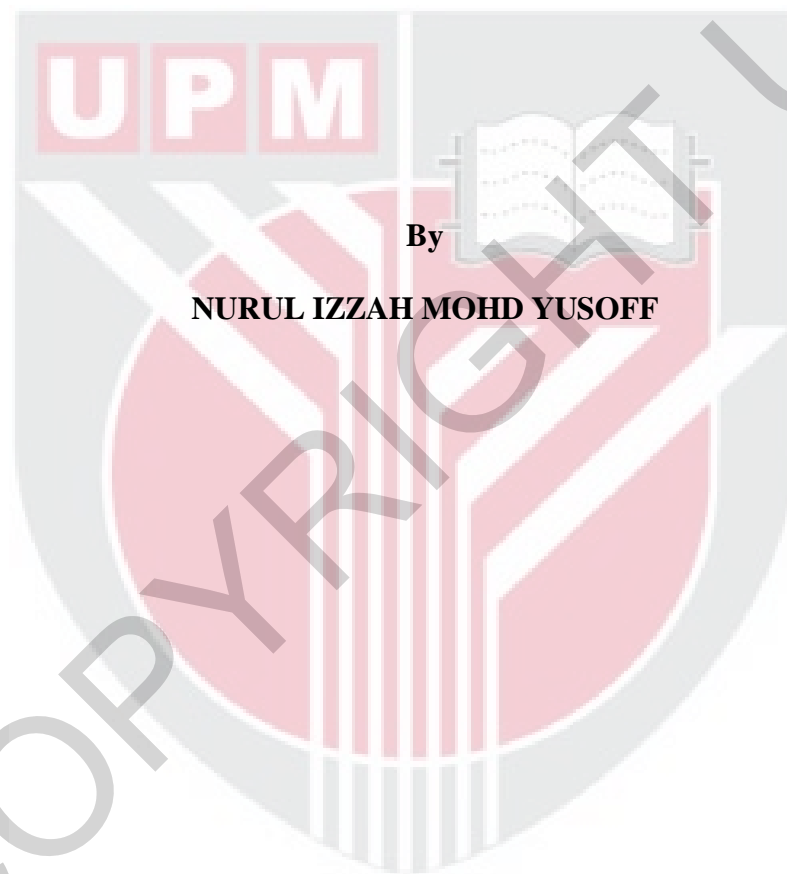
UNIVERSITI PUTRA MALAYSIA

***CHARACTERIZATION AND ANALYSIS OF ULTRA WIDEBAND
SIGNAL ABSORPTION RATES IN BREAST TISSUES***

NURUL IZZAH MOHD YUSOFF

FK 2011 153

**CHARACTERIZATION AND ANALYSIS OF ULTRA WIDEBAND SIGNAL
ABSORPTION RATES IN BREAST TISSUES**



By

NURUL IZZAH MOHD YUSOFF

**Thesis Submitted to the School of Graduate Studies, University Putra Malaysia, in Fulfillment of
the Requirement for the Degree of Master of Science**

May 2011

DEDICATION

To my parents, for their love and support.



© COPYRIGHT UPM

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

**CHARACTERIZATION AND ANALYSIS OF ULTRA WIDEBAND SIGNAL
ABSORPTION RATES IN BREAST TISSUES**

By

NURUL IZZAH MOHD YUSOFF

May 2011

Chairman: Professor Sabira Khatun, PhD

Faculty: Engineering

Microwave ultra wideband (UWB) technique has been extensively studied as a potential solution for non-ionizing breast cancer detection. Such technique exploits the significant contrast of dielectric properties between normal tissue and tumour with the exposure of UWB signals where the electric field interacts with biological tissue and produces signatures that can be used to differentiate normal over malignant tissue.

This research evaluates the interaction of electromagnetic field with layered breast tissue by a computational method of the Specific Absorption Rate (SAR). SAR analytical model for normal and tumour-affected breast tissues are estimated based on the method. SAR is then evaluated in three dimensional simulations of the normal and tumour-affected breast tissues. Parameters of biological tissues included are defined by Cole-Cole dielectric model.

Analysis shows that tumour conductivity gives rise to the characteristic of tissue attenuation. It significantly increases power density in all 1, 5 and 10 mm tumour-affected breast tissue compared to normal tissues. However, power density in tumour-affected tissue decreases with the size of tumour as a result of the exponential power degradation as the wave penetrates into the tumour at increasing depths. The absorption rate for normal and tumour-affected breast tissues is predicted by the proposed SAR analytical models. Increase of power density results in the increase of SAR values by 37.29%, 37.44% and 37.59% in 1, 5 and 10 mm tumour-affected breast tissues in comparison with the normal tissues. Evaluation by simulation model is in agreement with that of the proposed analytical model.

The study reveals the advantage of the method to interact with a slight change of tissue property which is demonstrated by the increased absorption rate in 1 mm tumour-affected breast tissue as opposed to the normal tissue. The characterization of UWB signal absorption rates by normal and tumour-affected breast tissues further indicates the feasibility of the method for breast cancer detection.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**PERINCIAN DAN ANALISIS TERHADAP KADAR PENYERAPAN
ISYARAT ULTRA JALUR LEBAR DALAM TISU PAYUDARA**

Oleh

NURUL IZZAH MOHD YUSOFF

Mei 2011

Pengerusi: Profesor Sabira Khatun, PhD

Fakulti: Kejuruteraan

Teknik ultra jalur lebar (*UWB*) gelombang mikro dikaji secara meluas sebagai salah satu penyelesaian berpotensi bagi pengesanan kanser payudara tanpa pengionan. Teknik tersebut mengeksploitasi perbezaan signifikan pada ciri dielektrik antara tisu normal dengan tumor dengan pendedahan isyarat *UWB* medan elektrik berinteraksi dengan tisu biologi dan menghasilkan tanda unik penyerapan untuk membezakan antara tisu normal dengan tisu yang tidak sihat.

Kajian ini menilai interaksi medan elektromagnet *UWB* terhadap tisu payudara berlapis menggunakan kaedah pengiraan Kadar Penyerapan Spesifik (*SAR*). Model analitikal *SAR* bagi tisu payudara normal dan yang terjejas oleh tumor dianggarkan berdasarkan kaedah tersebut. *SAR* bagi payudara normal dan yang terjejas oleh tumor kemudian dinilai secara simulasi tiga dimensi. Parameter-parameter bagi tisu biologi ditentukan oleh model dielektrik *Cole-Cole*.

Analisis menunjukkan bahawa sifat konduktiviti tumor menimbulkan ciri pelemahan gelombang dalam tisu tersebut. Ia dengan ketara meningkatkan kepadatan kuasa

dalam semua tisu yang terjejas oleh 1, 5 dan 10 mm tumor apabila dibandingkan dengan tisu normal. Walau bagaimanapun, kepadatan kuasa dalam tisu yang terjejas oleh tumor berkurangan apabila saiz tumor bertambah disebabkan oleh penyusutan kuasa secara eksponen yang berlaku apabila gelombang isyarat menembusi kedalaman tumor yang menokok. Kadar penyerapan bagi tisu payudara normal dan yang terjejas tumor dinilai menggunakan model analitikal *SAR* yang dicadangkan. Peningkatan kepadatan kuasa menyebabkan peningkatan nilai *SAR* sebanyak 37.29%, 37.44% and 37.59% dalam tisu payudara terjejas oleh 1, 5 dan 10 mm berbanding dengan tisu normal. Penilaian menggunakan model simulasi adalah seiring dengan penilaian menggunakan model analitikal yang dicadangkan.

Kajian ini mendedahkan kelebihan kaedah ini untuk berinteraksi dengan perubahan kecil pada sifat tisu yang ditunjukkan oleh peningkatan kadar penyerapan dalam tisu payudara yg terjejas oleh 1 mm tumor berbanding tisu normal. Perincian kadar penyerapan isyarat *UWB* oleh tisu payu dara normal dan terjejas tumor seterusnya menandakan keboleh-gunaan kaedah tersebut bagi pengesanan kanser payudara.

AKNOWLEDGEMENTS

Praise is to Allah, the Most Gracious and the Most Merciful.

I wish to thank Prof. Dr. Sabira Khatun for her guidance, advice and fiscal support throughout the project.

My gratitude goes out to Dr. Raja Syamsul Azmir Raja Abdullah and Dr. Alyani Ismail for their assistance and comments in improving the research.

I also wish to express my appreciation to Mr. Chiang Chun Tong of CST Technology for providing information and technical supports regarding software application.

A special appreciation goes to Khairi Budayawan for giving me the permission to use one of his antenna design.

Lastly I would like to thank my friends of the lab; Ayoub, Bassam, Yaqob, A'ala, Octarina, Sabarina and Dr. Michael for sharing knowledge and experience.

APPROVAL

I certify that a Thesis Examination Committee has met on 23 May 2011 to conduct the final examination of Nurul Izzah Mohd Yusoff on her thesis entitled “Characterization and Analysis of Ultra Wideband Signal Absorption Rates in Breast Tissues” in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee are as follows:

M. Iqbal Saripan, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Nor Kamariah Noordin, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohd Adzir Mahdi, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Suhaili Zakaria, PhD

Lecturer
Faculty of Science
Universiti Teknologi Malaysia
(External Examiner)

SEOW HENG FONG, PhD

Professor and Deputy Dean
School Of Graduate Studies
University Putra Malaysia

Date: 22 November 2011

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Sabira Khatun, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Alyani Ismail, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Raja Syamsul Azmir Raja Abdullah, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

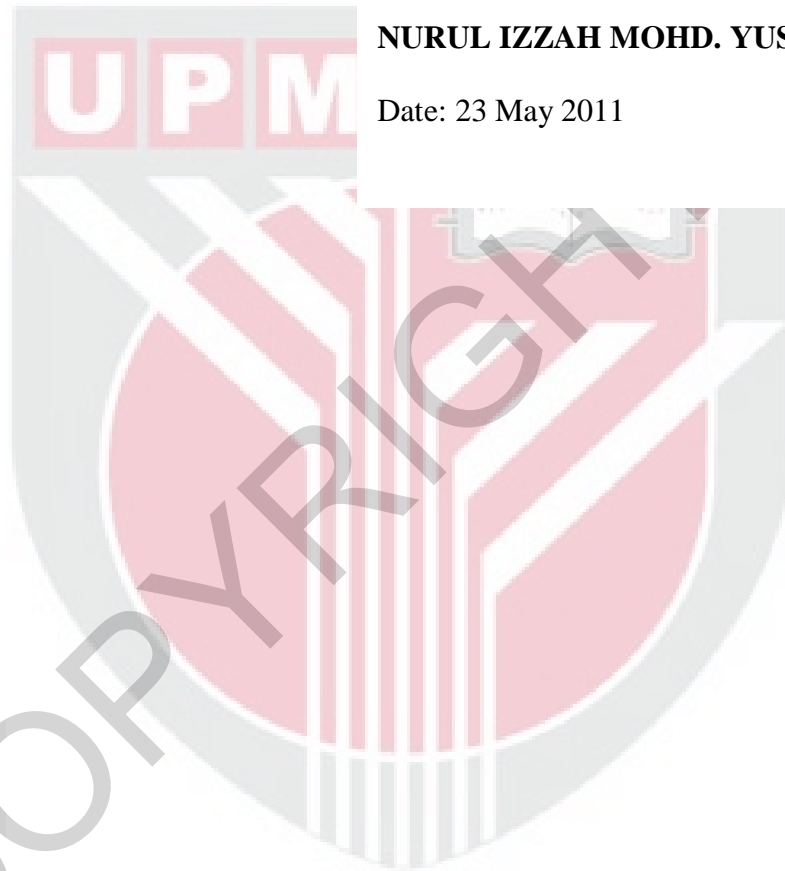
BUJANG BIN KIM HUAT, PhD

Professor and Dean
School Of Graduate Studies
University Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



NURUL IZZAH MOHD. YUSOFF

Date: 23 May 2011



TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	viii
DECLARATION	x
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiv
LIST OF SYMBOLS	xv
CHAPTER	
1 INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement and Motivation	3
1.3 Research Aim and Objectives	3
1.4 Scope of Thesis	4
1.5 Thesis Organization	5
2 LITERATURE REVIEW	6
2.1 Ultra Wideband	6
2.1.1 Bandwidth and Power Spectral Density	7
2.1.2 Average Power Emission	9
2.2 Electromagnetic Field Theory	10
2.2.1 Maxwell's Equations	10
2.2.2 Boundary Conditions	12
2.3 The Finite Integration Technique (FIT)	13
2.3.1 Faraday's Law	18
2.3.2 Ampere's Law	19
2.3.3 Gauss' Law	20
2.3.4 Magnetic Law	21
2.4 Biological Materials	22
2.4.1 Dielectric Model of Tissue	23
2.4.2 Description of Tumour	26
2.5 Absorption as Influence of Electric Field on Tissue	27
2.6 Related Research of Specific Absorption Rate (SAR)	28

3 METHODOLOGY	32
3.1 Overview	32
3.2 Analytical Model of SAR for Normal and Tumour-Affected Breast Tissues	34
3.2.1 Method for Evaluating Intrinsic Impedance and Attenuation Constant	34
3.2.2 Method for Evaluating Power Density	36
3.2.3 Method for Evaluating SAR for Normal and Tumour-Affected Breast Tissues	39
3.3 Simulation Model of SAR for Normal and Tumour-Affected Breast Tissues	43
3.3.1 Signal Model	45
3.3.2 3D Simulation Model	45
4 RESULTS AND ANALYSIS	47
4.1 Overview	47
4.2 Data and Specifications	47
4.2.1 Electromagnetic Properties of Tissue	48
4.2.2 Antenna Characteristics, Tissue Volume and Incident Power Density	48
4.3 Results and Analysis of Analytical Model	51
4.3.1 Results and Analysis of Intrinsic Impedance and Attenuation Characteristics	52
4.3.2 Results and Analysis of Tissue Power Density	54
4.4 Comparison of Analytical Model with Simulation Model	56
4.4.1 SAR as Function of Tumour Size	56
4.4.2 SAR as Function of Tumour Cell Distance	57
4.4.3 Power Pattern of SAR in 3D Simulation	59
5 CONCLUSIONS AND FUTURE WORK	61
5.1 Conclusions	61
5.2 Contributions	61
5.3 Recommendation for Future Work	62
REFERENCES	64
APPENDIX	68
BIODATA OF STUDENT	82
LIST OF PUBLICATIONS	83