UNIVERSITI PUTRA MALAYSIA

SIMULATION OF MICROWAVE BISTATIC RADAR FOR BREAST CANCER DETECTION APPLICATION

OCTARINA NUR SAMIJAYANI

FK 2011 76
SIMULATION OF MICROWAVE BISTATIC RADAR FOR BREAST CANCER DETECTION APPLICATION

By

OCTARINA NUR SAMIJAYANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

May 2011
DEDICATION

This thesis is especially dedicated To

My beloved parents, my sisters and all my dearest friends
SIMULATION OF MICROWAVE BISTATIC RADAR FOR BREAST CANCER DETECTION APPLICATION

By

OCTARINA NUR SAMI JAYANI

May 2011

Chairman : Y.M Raja Syamsul Azmir bin Raja Abdullah, PhD
Faculty : Engineering

The implementation of microwave active imaging technique for breast cancer detection is being developed recently and highly supported by the property of tumor which has high contrast in electrical properties compared to normal breast tissue. The tumor causes a significant scattering than normal tissue when exposed in microwave. Ultra wideband (UWB) microwave bistatic radar is simulated with a moving transmitter in the edge of breast utilizing the Doppler parameter for breast cancer detection. Doppler frequency is derived in terms both the changing of UWB pulse width and Pulse Repetition Frequency (PRF). The received signal is modelled and then processed using three Doppler Extraction Methods; Power Frequency Analysis, Correlation Method, and Doppler Frequency Separation.
Doppler Frequency Separation is a better technique to extract the Doppler feature. Although the frequency changing caused by the Doppler Effect in this proposed system is small enough compared to its carrier frequency, the comparison result using correlation coefficient formula obtains the feasibility of this proposed radar to differentiate between a healthy and cancerous breast is about 0.2-0.5 of dissimilarity level.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SIMULASI RADAR BISTATIK GELOMBANG MIKRO UNTUK APLIKASI PENGESANAN BARAH PAYUDARA

Oleh

OCTARINA NUR SAMIJAYANI
Mei 2011

Pengerusi : Y.M Raja Syamsul Azmir bin Raja Abdullah, PhD
Fakulti : Kejuruteraan

Pelaksanaan teknik pengimejan aktif gelombang mikro untuk pengesanan barah payudara sedang dibangunkan pada masa kini dan amat disokong oleh sifat ketumbuhan yang mempunyai perbezaan ketara dari segi sifat elektrikal berbanding tisu payudara normal. Ketumbuhan akan menyebabkan satu selerakan yang ketara berbanding tisu normal apabila didedahkan kepada gelombang mikro. Radar bistatik gelombang mikro jalur luas ultra (UWB) disimulasikan dengan suatu penghantar bergerak di pinggir payudara dengan menggunakan parameter Doppler untuk pengesanan ketumbuhan/barah. Frekuensi Doppler diterbitkan dari kedua-dua segi iaitu perubahan lebar denyut UWB dan frekuensi pengulangan denyut (PRF). Isyarat
diterima dimodelkan dan diproses menggunakan tiga kaedah pengekstrakan Doppler; analisis frekuensi kuasa, kaedah korelasi dan pemisahan frekuensi Doppler.

Pemisahan frekuensi Doppler merupakan teknik yang lebih baik untuk mengestrak ciri Doppler. Walaupun perubahan frekuensi yang disebabkan oleh Doppler di dalam sistem yang dicadangkan ini adalah cukup kecil berbanding frekuensi pembawa 6GHz, perbandingan hasil menggunakan formula pekali korelasi mencapai keboleharapan radar yang dicadangkan untuk membezakan payudara sihat dan payudara yang dijangkiti barah adalah sekitar ketidaksamarataan 0.2-0.5.
ACKNOWLEDGEMENT

Alhamdullilahiobila’lamin, praise is to ALLAH SWT the Almighty for His infinite blessings and opportunities to finish this thesis and peace is upon the prophet Mohammad as our best leader.

I would like to express my sincerest gratitude to advisor, Y.M Raja Syamsul Azmir bin Raja Abdullah, PhD. I am grateful for his support, kindness and thoughtful advices throughout this research. I would also like to thanks to my co supervisors Dr. Alyani Ismail and Dr. M. Iqbal Saripan, for the encouragement and suggestions during this research. Also I would like to thanks to Ary Syahriar, DIC who has given me support to take study abroad.

I would like to give huge thanks from deep inside of my heart to my mother and my father. Thanks for being the infinitive source of love. Thanks to my beloved sisters, Rani Chandra Oktaviani and Mayriska Tri Wulansari for all the extraordinary inspiration and imaginations which always bring the spirits and hopes.

Special thanks to my friends in KKK Laboratory, Faculty of Engineering, UPM, for their technical help and supports. I would also like to thank to my house-mates, all my friends in PPI-UPM, and all the staff in UPM for their support and encouragement. Also thanks to my dearest friends from Etniez that never tired giving me the spirits. I wish to Allah to have mercy, peace and prosperity for my country (Indonesia) and I would like to express my thanks to (Malaysia) the beautiful country for its convenience to stay.
I certify that a Thesis Examination Committee has met on 31st May 2011 to conduct the final examination of **Octarina Nur Samijayani** on her thesis entitled “Simulation of Microwave Bistatic Radar For Breast Cancer Detection Application” in accordance with the Universities and University Colleges 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 Thesis Examination Committee were as follows:

**Khairulmizam b. Samsudin, PhD**  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Ratna Kalos Zakiah bt. Sahbudin, PhD**  
Faculty of Engineering  
Universiti Putra Malaysia  
(Internal Examiner)

**Aduwati bt. Sali, PhD**  
Faculty of Engineering  
Universiti Putra Malaysia  
(Internal Examiner)

**Mohamad Kamal A Rahim, PhD**  
Associate Professor  
Faculty of Electrical Engineering  
Universiti Teknologi Malaysia  
Malaysia  
(External Examiner)

---

**NORITAH OMAR, PhD**  
Associate Professor and Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia  

Date: 23 August 2011
This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

**Y.M Raja Syamsul Azmir Bin Raja Abdullah, PhD**  
Senior Lecturer  
Faculty of Engineering  
University Putra Malaysia  
(Chairman)

**Alyani Binti Ismail, PhD**  
Senior Lecturer  
Faculty of Engineering  
University Putra Malaysia  
(Member)

**M. Iqbal Saripan, PhD**  
Senior Lecturer  
Faculty of Engineering  
University Putra Malaysia  
(Member)

---

**HASANAH MOHD GHAZALI, PhD**  
Professor and Dean  
School of Graduate Studies  
Universiti 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 at any other institution.

_______________________________________________
OCTARINA NUR SAMIJAYANI

Date: 31 May 2011
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>DEDICATION</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>v</td>
</tr>
<tr>
<td>ACKNOWLEDGMENT</td>
<td>vi</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>vii</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xiii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xiv</td>
</tr>
</tbody>
</table>

## CHAPTER

### 1. INTRODUCTION

1.1 Background
1.2 Problem Statement
1.3 Objectives of Research
1.4 Scope of Research
1.5 Methodology Research
1.6 Benefits of Research
1.7 Research Outline

### 2. LITERATURE REVIEW

2.1 Breast Cancer Detection
2.2 Microwave Imaging
   2.2.1 Tomography Microwave Imaging
   2.2.2 Radar Based Microwave Imaging
2.3 Radar Principle
   2.3.1 Radar Configuration
   2.3.2 Radar in Medical Application

### 3. METHODOLOGY

3.1 Research Framework
3.2 Proposed Radar System
3.3 UWB Signal
3.4 Doppler Analysis
   3.4.1 Doppler from the Changing of Pulse Width
   3.4.2 Doppler from the Changing of PRF
3.5 Relative Velocity Formulation 38
  3.5.1 Relative Velocity for Direct Signal 38
  3.5.2 Relative Velocity for the Scattered Signal 39
3.6 Doppler Feature Extraction Method 40
  3.6.1 Power Frequency Analysis 42
  3.6.2 Correlation Method 44
  3.6.3 Doppler Frequency Separation 47

4. RESULTS AND ANALYSIS
  4.1 Parameter of Radar 53
  4.2 Transmitted Signal 54
  4.3 Doppler Frequency 56
  4.4 Received Signal 60
    4.4.1 Received Signal in Healthy Breast 60
    4.4.2 Received Signal in Cancerous Breast 62
  4.5 Doppler Feature Extraction 63
    4.5.1 Power Frequency Analysis 64
    4.5.2 Correlation Method 69
    4.5.3 Doppler Frequency Separation 73
  4.6 Comparison of Doppler Extraction Method 80
  4.7 Characteristic of Proposed Radar Design 82
    4.7.1 Simulation result with different location of tumor 83
    4.7.2 Simulation result with different UWB pulse width 85
    4.7.3 Simulation result with different scanning velocity 86
    4.7.4 Simulation result with different size of breast 87

5. CONCLUSIONS
  5.1 Conclusions 89
  5.2 Contributions 90
  5.3 Recommendations for Future Research 90

REFERENCES 91
APPENDIX A 96
APPENDIX B 100
BIODATA OF STUDENT 104