UNIVERSITI PUTRA MALAYSIA

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

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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

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DEDICATION

To my parents, for their love and support.

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

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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 mengekspoitasi perbezaan signifikan pada ciri dielektrik antara tisu normal dengan tumor dengan pendedahan isyarat *UWB* medan elektrik berinteraksi dengan tisu biologi dan menghasilkan tanda unik penyerakan untuk membezakan antara tisu normal dengan tisu yang tidak sihat.

Kajian ini menilai interaksi medan elekromagnet *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.

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APROVAL

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.

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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:

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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

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