ELECTROMAGNETIC RADIATION BETWEEN PACEMAKER AND CELLULAR PHONE WITH THE HUMAN BODY IN CLOSE PROXIMITY

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DEDICATION

To lovely husband, for his love and being very understanding and supportive in keeping me going, enduring the ups and downs during the completion of this thesis.

To my lovely mother and mother in-law, who gave me endless love, trust, constant encouragement over the years, and for their prayer's.

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ABSTRACT

A pacemaker is a small device that's placed in the chest or abdomen to help control the abnormal heart rhythms. Pacemaker telemetry is used for communicate with other communication devices and the suitable operating frequency used is 402-405 MHz. The issues concerning cellular phones are the electromagnetic radiation (EMR) that the devices produce. The most of the interference related to disturbance the signal is on cardiac monitors. The aims of this project are to determine the interference between mobile antenna 2.4 GHz and 900 MHz towards antenna 402 MHz. Second is to measure the transmission coefficient between two antennas with the presence of human body. The distance source has been taken into account in this project. Antenna with operating frequency 900 MHz and 2.4 GHz was simulated with and without non-homogenous body phantom and measured it as validation purposes. The mobile antenna with frequency 2.4 GHz and 900 MHz also simulated with the pacemaker telemetry antenna 402 MHz and measured the performance in terms of power absorption with varied the distance between mobile antenna and pacemaker antenna. Besides, the thickness of the human body also taken into account. SAR simulation has been done for precise the result of the performance in terms of power absorption from antenna operating 2.4 GHz and 900 MHz towards 402 MHz antenna. As a result, the performance in terms of power received between antenna 2.4GHz and 900 MHz towards antenna 402 MHz was comply with FCC standard compliances which is below -16 dBm. The higher the distance gives the lower power received which is -25 dBm instead of 10mm distance gives -18 dBm in terms of power received. The SAR simulations for antenna operating frequency 900 MHz and 2.4 GHz with non-homogenous body phantom with varied the thickness in between 1mm to 10mm were also complying the FCC compliances (below 1.6 Kg/W). The SAR value is increase with the increasing distance and thickness of fat tissue in body phantom.

ABSTRAK

‘*Pacemaker*’atau perentak jantung adalah peranti kecil yang diletakkan di dada atau badan untuk membantu mengawal irama jantung yang tidak normal. Telemetri pacemaker digunakan untuk berkomunikasi dengan peranti komunikasi lain dan kekerapan operasi yang sesuai digunakan ialah 402-405 MHz. Isu mengenai telefon selular adalah radiasi elektromagnet (EMR) yang memberi kesan terhadap peranti. Kebanyakan gangguan yang berkaitan dengan gangguan isyarat adalah pada monitor jantung. Objektif projek ini adalah untuk menentukan gangguan antara antena mudah alih 2.4 GHz dan 900 MHz ke arah antena 402 MHz. Kedua adalah untuk mengukur pekali penghantaran antara dua antena dengan kehadiran tubuh manusia. Parameter jarak telah diambil kira dalam projek ini. Antena dengan frekuensi operasi 900 MHz dan 2.4 GHz disimulasikan dengan dan tanpa prototaip tisu badan manusia dan mengukurnya sebagai tujuan pengesahan. Antena mudah alih dengan frekuensi 2.4 GHz dan 900 MHz juga disimulasikan dengan antena telemetri pacemaker 402 MHz dan mengukur prestasi dari segi penyerapan kuasa dengan mengubah jarak antara antena mudah alih dan antena alat *pacemaker*. Selain itu, ketebalan tubuh manusia juga diambil kira. Simulasi SAR telah dilakukan untuk memastikan keputusan prestasi dari segi penyerapan kuasa daripada antena berfrekuensi 2.4 GHz dan 900 MHz ke arah antena 402 MHz. Kemudian, prestasi dari segi kuasa yang diterima antara antena 2.4 GHz dan 900 MHz ke arah antena 402 MHz mematuhi pematuhan standard FCC yang berada di bawah -16 dBm. Semakin tinggi jarak memberikan kuasa yang lebih rendah yang diterima iaitu -25 dBm dan bagi jarak 10mm memberikan -18 dBm dari segi kuasa yang diterima. Simulasi SAR untuk frekuensi operasi antena 900 MHz dan 2.4 GHz dengan prototaip badan yang tidak homogen dengan variasi ketebalan antara 1 mm hingga 10 mm juga mematuhi pematuhan FCC (di bawah 1.6 Kg / W). Nilai SAR meningkat dengan peningkatan jarak dan ketebalan tisu lemak di dalam badan.

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LIST OF ABBREVIATIONS

EMI	-	Electromagnetic Interferences
EMR	-	Electromagnetic Radiation
FCC	-	Federal Communication commission
SAR	-	Specific Absorption Rate

LIST OF SYMBOLS

λ	-	Wavelength
ε	-	Permittivity
ε_r	-	value of dielectric substrate
c	-	Speed of light

CHAPTER 1

INTRODUCTION

1.1 Introduction Overview

Recently, developments in electronics industry are major contributions to the widespread use of microwave and radio frequency (RF) devices including telecommunication, radio, radar and biomedical applications. Therefore, influence with the electromagnetic (EM) wave emitted from these devices is widely concerned. Currently, mobile cellular phones and other wireless communication devices are widely used by in-hospital care providers. Most cellular phones have either a small antenna attached or integrated into internal parts.

The antennas from these phones produced exposure than other types of RF systems through transmits and receive data [1]. Human exposure to RF fields in excess of the limit may lead adverse health effect. EM radiation absorbed energy in the human body mainly imparts a thermal effect of tissues. The specific absorption rate (SAR) is used as the standard parameter for international safety guidelines [2] for exposures. The induced exposure and rising thermal can cause Electromagnetic interference (EMI) to the susceptible implanted medical devices especially for heart pacemaker wearer.

Electromagnetic interference (EMI) can be defined as any signal, either biologic or non-biologic, that falls within a frequency spectrum that are being detected by the sensing circuitry of the pacemaker. They can interfere with the optimal function of the pacemaker and is always a concern for the patients with a pacemaker, since the risk of EMI is greatest in pacemaker dependent patients. EMI may potentially affect a pacemaker in one of three ways: Stopping the pacemaker from delivering the stimulating pulses that regulate heart's rhythm; causing the pacemaker to deliver the irregularly; and causing the pacemaker to ignore heart's own rhythm and deliver pulses at a fixed rate. The interference may cause pacemaker malfunctions and affects irritation, discomfort and an illness to pacemaker wearer health.

Therefore, this project focuses on the interference due to cellular phone on pacemaker at three different operating frequencies which are 900 MHz and 2.4GHz. The relationship between transmission power, frequency, and radiation source mode will be taken into account in this project. The cellular phone antenna will be simulated in close proximity to human body with implanted pacemaker. The distance between the antenna and the body will be varied. In addition to that, the property of the human body such as skin thickness, the complexity of human body tissue will also be considered in this project.

1.2 Problem statement

The number of pacemaker patient has been increase with expanding indications for device therapies for management of cardiovascular diseases. It is used for treatment of cardiac arrhythmia. The pacemaker will trigger the pulse of heartbeat to stimulate at normal pulse if the pulse beat too slow or too fast. Cellular phone and PDA’s are commonly used for personal and professional scheduling accessing in by the medical practitioner and also the pacemaker wearer. By theoretically, the electromagnetic interference (EMI) from the cellular phone antenna may affect to the pacemaker wearer [3]. The pacemaker may acts as a receiving antenna with respect to the EMI from the cellular phone. The absorbed EMI energy in the human body mainly imparts a thermal effect of tissues. The specific absorption rate (SAR) is used as the standard parameter for international safety guidelines [4] for radio frequency exposures.

This research focuses on investigating the EMI due to cellular phone and pacemaker and takes into account the SAR value around the pacemaker in multiple operating frequencies. The relationship between transmission power, frequency, and radiation source mode will be further investigated. Recent researches have considered various type of antenna in order to used as a cellular phone, dipole antenna, multiband antenna and 3G antenna with multiple operating frequency, 450 MHZ, 900 MHz, 1800 MHz and 2400 MHz. most of the researcher measure the interference between pacemaker and the cellular phone base on actual measurement. Some of the researcher using numerical method to evaluate the SAR value around the pacemaker and not take into accounts the complexity of human body. Most of the research only evaluates the SAR in human body radiated by cellular phone at human head instead of body. Thus this research will focuses in simulating the cellular phone antenna in close proximity to human body with implanted pacemaker. The distance between the antenna and the body will be varied. In addition to that, the property of the human body such as skin thickness, the complexity of human body tissue will also be considered in this project. Furthermore, the SAR value should be considered in the simulating and measuring the EMI from the cellular phone and the implanted pacemaker.

1.3 Research objectives

The main objective of this research is to investigate the EMI from cellular phone to the implanted pacemaker.

The objectives summaries for this project are:

1) To determine the Electromagnetic radiation between pacemaker and cellular phone

2) To measure the Electromagnetic radiation absorption at various body properties.

1.4 Scope of project

This research will be done based on the following scope:

1. Microstrip antennas operating at 900 MHz and 2.4 GHz have been design and simulated using CST Microwave Studio.

2. SAR value is simulated in different body properties with different thickness of human body layer. The skin thickness range (2mm-3.5mm), fat thickness range (1mm-10mm) will consider in the project. Then distance between the cellular phone and the human body has been varies in range (10mm-100mm) and the acceptance SAR value is following the FCC regulations.

3. The power received have been simulated from 2.4 GHz & 900 MHz antenna with the 402 MHz antenna pacemaker model

4. The power received have been measured from 2.4 GHz & antenna with the 402 MHz antenna in liquid phantom

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