SIGNAL INTERFERENCE TO ELECTROENCEPHALOGRAM AND ELECTROCARDIOGRAM SIGNAL

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical)

Faculty of Electrical Engineering
UniversitiTeknologi Malaysia

FEBRUARY 2015

Specially dedicated to

My beloved father and mother,

To my family members and friends

Thanks for all the encouragement and support

ACKNOWLEDGEMENT

Alhamdullillah, Praise to Allah S.W.T, The Most Compassionate and Gracious for His blessing and guidance along this journey in completing my thesis. In this short column, I would like to express my gratitude for the support from people around me in accomplishing this journey.

In particular, I wish to express my sincere appreciation to my main supervisor, Associate Professor Dr RubitaBintiSudirman, for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisor Dr NasrulHumaimi Bin Mahmood for the guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here. Besides, I want to thank to all the techniciansof the Medical Electronic Laboratory and Electronic Industry Laboratory for helping me throughout the semesters.My sincere appreciation also extends to all the respondents who had helped me in the experimental and technical work.

Most importantly, I would like to convey my special deepest thanks to my dearest parents, Abdul Samad Bin Samungin and HasnahBinti Ahmad, who had persistently giving spiritual motivation and inspiration throughout my study. With their concern and support, I managed to motivate myself to finish this study.

Last but not least, I would like to dedicate my great appreciation to all my friends for their useful views and tips for the development of this project and also for them who is involved indirectly. Again, my sincere thanks and appreciation is extended to all of you.

ABSTRACT

The increment in a number of electric and electronic devices nowadays ignites the curiosity about the effect of Electromagnetic Interference (EMI) coming from those devices especially in medical environment. In general, the probability for EMI incidents to occur is small. However, the effect from the incident could lead to a very fatal and hazardous side effect. This study strictly focuses on the effect of electromagnetic interference from medical devices that are placed close to the electrocardiogram (ECG) and electroencephalogram (EEG) devices during ECG and EEG signal acquisitions. Since both ECG and EEG machine are most crucial equipments to examine critical part of human body, the devices should be handled with extra precaution towards EMI contamination. An analysis was carried out by using the Fast Fourier Transform (FFT) and QRS Wave Peak Detection to study the effect of EMI from several types of medical devices on both ECG and EEG signals. The result of analysis on the signal exposed to the interference from medical devices was compared to the signal obtained in environment without medical devices.The results showed that interference from blood pressure cuff, electroglotograph, ultrasound, microspirometer and electro muscle stimulator disturbed the quality of signal displayed as well as the amplitude and frequency component of the ECG and EEG signals at 0 cm distance. Even though the EMI can be easily filtered out by using highpass and lowpass filter, the noise can be misinterpreted as a symptom of arrhythmia and consequently leads to unnecessary treatment and panic situation on medical staff.

ABSTRAK

Peningkatan dalam jumlah alatan elektrik dan elektronik pada hari ini membangkitkan rasa ingin tahu tentang kesan gangguan elektromagnetik (EMI)*'*yang dihasilkan oleh alatan tersebut terutamanya dalam persekitaran perubatan. Secara umumnya, kebarangkalian bagi kejadian EMI untuk berlaku adalah kecil. Walaubagaimanapun, kesan daripada kejadian tersebut boleh membawa kepada kesan sampingan yang boleh mendatangkan maut dan sangat berbahaya. Kajian ini memberi tumpuan kepada kesan gangguan elektromagnetik dari alat-alat perubatan yang diletakkan berhampiran dengan alat *'electrocardiogram* (ECG) *'*dan alat *'electroencephalogram* (EEG)*'* semasa mendapatkan isyarat ECG dan EEG. Memandangkan mesin ECG dan EEG adalah peralatan paling penting untuk memeriksa bahagian kritikal dalam badan manusia, peranti tersebut harus dikendalikan dengan lebih berhati-hati terutamanya terhadap gangguan EMI. Satu analisis telah dijalankan dengan menggunakan Jelmaan Fourier Pantas dan Pengesan Puncak Gelombang QRS untuk mengkaji kesan EMI dari beberapa jenis alat perubatan ke atas isyarat ECG dan EEG. Hasil analisis ke atas isyarat yang terdedah kepada gangguan dari peranti perubatan dibandingkan dengan isyarat yang diperolehi dalam persekitaran tanpa peranti perubatan. Hasil kajian menunjukkan bahawa gangguan dari pengukur tekanan darah tinggi, '*electroglotograph*', '*ultrasound*', '*microspirometer*' dan '*electro musle stimulator'* mengganggu kualiti isyarat serta amplitud dan komponen frekuensi bagi isyarat ECG dan EEG. Walaupun EMI mudah disingkirkan dengan menggunakan penapis lulus tinggi dan penapis lulus rendah, kebisingan boleh disalah tafsir sebagai petanda *'arrhythmia'* dan seterusnya membawa kepada rawatan yang tidak perlukan dan situasi panik kepada staf perubatan.

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LIST OF SYMBOLS

Hz	-	Hertz
K	-	Sample points
m	-	Meter
N	-	Number of samples
s	-	Second
T1	-	Time at point 1
T2	-	Time at point 2
V	-	Volt
$Y(n)$	-	Electrocardiogram signal in frequency domain
$y(k)$	-	Electrocardiogram signal in time domain
$y(n)$	-	Output signal
$x(n)$	-	Input signal
µ	-	Micro

LIST OF ABBREVIATIONS

AM	-	Amplitude modulation
BPM	-	Beat per minute
CDMA	-	Code division multiple access
DFT	-	Discrete Fourier transform
ECG	-	Electrocardiogram
EEG	-	Electroencephalogram
EMC	-	Electromagnetic compatibility
EMG	-	Electromyogram
EMI	-	Electromagnetic interference
EOG	-	Electrooculography
FDA	-	Food and Drug Association
FFT	-	Fast Fourier transform
FM	-	Frequency modulation
GSM	-	Global system for mobiles
HPF	-	High pass filter
ICD	-	Implantable cardiac defibrillator
IEC	-	International Electrotechnical Commission
LA	-	Left arm
LL	-	Left leg
LPF	-	Low pass filter
MATLAB	-	Matrix Laboratory
MI	-	Myocardial infarction
MRI	-	Magnetic resonance imaging
RA	-	Right arm
RFID	-	Radio frequency identification
SKMM	-	Malaysian Communications Multimedia Commission
USA	-	United State of America

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CHAPTER 1

INTRODUCTION

1.1 Overview

A very highlevel of dependencyon thetechnologyin the medical fieldmakes thereductionof electronic goodsin themedicalenvironmentimpossible. In fact, the proliferations of electronic goods are expected tooccurfromtimeto time.This phenomenon ignited the curiosity of many researchers to study about the effect of electromagnetic interference coming from those devices.Authors from different countries and different background of study start reviewing about the sources and impact of electromagnetic interference especially in medical environment.Sources of electromagnetic interference can be classified into several type such as; medical devices (electro surgery units), personal items (mobile phone, computers, walkie-talkie), electric power supply (electric generators, motors) and entertainment items (televisions, AM/FM radios)(Col & Varkey, 1995; Fernández-chimeno & Silva, 2010; Luca & Salceanu, 2012).Those listed items are possible in producing and emitting electromagnetic interference energy and some of it could bring hazardous effect due to their high level of electromagnetic interference radiation.

Since the usage of mobile phone becoming a trend and habit of human being, several issues on its negative impact due to the emission of electromagnetic interference energy are being studied. Family members, health care centre staff and even patient who stayed in the health care centre frequently use mobile phone. The usage of mobile phone become more and more significant as the ‘smart phone’ being introduceworld wide. Thus, mobile phone unanimously became the most commonsources of electromagnetic interference in medical environment(Wong *et al.*, 2012). Several authors had written cases related to the effect of electromagneticradiated by mobile phone. Most of them agreed to avoid the usage of mobile phone in medicalenvironment especially within the area that contains sensitive equipment that easily susceptible to electromagnetic interference(Fernández-chimeno & Silva, 2010).

Other most common source of electromagnetic interference is coming from radio frequency identification (RFID). The study which conducted by van Lieshout*et al.*, has concluded that radio frequency identification (RFID) can lead a potentially risky incidents in medical devices.Togt*et al.*(2008), also stated that radio frequency identification (RFID) could give greater negative impact compare to mobile phone(Togt *et al.*, 2008). Since there are cases reported happened due to the electromagnetic interference from mobile phone and radio frequency identification (RFID), thus it is possible for a medical device to affect the performance of other medical device.

This study strictly focuses on the effect of electromagnetic interference during electrocardiogram (ECG) and electroencephalogram (EEG) acquisition. This is because both equipments are easily susceptible towards ambience signal (Luca & Salceanu, 2012). Electrocardiogram signal is a low amplitude signal, range between 0.5mV to 4mV with frequency range of 0.05Hz to 100Hz. Meanwhile, electroencephalogram signal is also a signal with very low amplitude which is merely less than 100µV, 100Hz. Those characteristic makes the signals easily interrupted by other signals. During analysis of data of both signals, the biggest problem encountered by the analyzer is how to extract true signal from the noise signal existing in the environment. Since both electroencephalogram and electrocardiogram are most crucial medical equipment in term of their function to examine critical area of human body, extra prevention on electromagnetic interference on both devices should be taken. Wrong interpretation of data may lead to serious harm or even dead (Fernández-chimeno & Silva, 2010).

1.2 Problem Statement

Even with the development of more advance technology of ECG and EEG, there are still problems on interference to EEG and ECG signals. Many attempts have been made to detect and eliminate the source of noises and artifacts from the original EEGs and ECGs signals. Several studies have been done to observe and study the EMI effect, however most of it only focusing on the electromagnetic interference (EMI) effect of mobile phone during EEG and ECG acquisition.

Since recent studies had shown that different environment or situation of the data acquisition can affect the measured data of ECGs and EEGs, investigation on the respondent should be done in order to provide a more reliable data for analysis. In this study, data acquisition of ECG and EEG was taken during the operation of other types of medical devices.The result of this study is significant for the health care centre that locates their medical device in close distance to each other.

1.3 Objectives of the Study

The main objective of this study was to model the situation based environment on the acquired ECG and EEG signals based on the extracted features (amplitude and frequency). The amplitude and frequency of ECG and EEG signal were analyzed to observe the effect of electromagnetic interference emitted from different type of medical devices available in the Medical Electronic Lab.

Second objective for this study was to measure and observe the noise in the signal received from ECG and EEG. The level of seriousness of the effect of electromagnetic interference in the ECG and EEG signal is determined by measuring the noise.

Last but not least, this study was done to recommend methods to reduce the electromagnetic interference effects caused by the situation of the environment. Theoretical and practical method was proposed. The proposed method can be applied to real situation depending on the level of interference and cost of the method.

1.4 Scope of the Study

In order to fulfil the objectives of the research, several scopes have been specified. The scope of this study involves two parts which are data acquisition and data analysis. For data acquisition, the measurementswere taken at different conditions of surroundings. Seven types of medical devices were operated during ECG and EEG data acquisition, one at a time. A control environment (without medical device) was set as a reference. KL-75001 Electrocardiogram Module and Electroencephalogram Module were used to take ECG and EEG signal from several respondents. The signals taken were displayed through oscilloscope. The data also can be displayed through MATLAB software to be further analyzed. For data analysis, QRS detection method is utilized to perform ECG signal analysis while Power spectral analysis is utilized for EEG signal analysis.

1.5 Thesis Outline

The completion of this study is elaborates in six different chapters. Chapter 1 elaborates the basic and main structure for the whole study. The problem statement, objectives of the study and the scope of the study are discussed in this chapter. This chapter also explains the expected outcome of the study.

Chapter 2 introduces the various literature reviews including the prior research that have been conducted related to effect of electromagnetic interference on medical device. It also includes the background of ECG, EEG, and EMI, method to manage the occurrence of EMI and standard that relates to the medical device and review on related previous works.

Chapter 3 discusses the methodology of this study. This chapter elaborates the procedures of experiment, theenvironment of the experiment, the medical devices used and the method of the analysis. The methodology for both ECG and EEG experiment are discussed discretely in this chapter.

Chapter 4 discusses about the result of the acquired data. The ECG and EEG signal from each experiment are compared and observed to see the effect of electromagnetic interference contaminated in the signal.

Chapter 5 concludes the whole study. The effect of electromagnetic interference in medical environment is summarized in this chapter. In addition, this chapteralso discusses on the recommendation to improve future study.

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