

**UNIVERSITI TEKNOLOGI MARA**

**DESIGN AND DEVELOPMENT OF  
AN OPTICAL BLOOD GLUCOSE  
MEASUREMENT FOR INFRARED  
AND NEAR-INFRARED TESTING**

**SARAH ADDYANI BINTI SHAMSUDDIN**

Thesis submitted in fulfillment  
of the requirements for the degree of  
**Master of Science**

**Faculty of Electrical Engineering**

**March 2015**

## AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless other is indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student : Sarah Addyani binti Shamsuddin

Student I.D. No. : 2011187861

Programme : Master of Science (Biomedical Engineering)

Faculty : Electrical Engineering

Thesis Title : Design and Development of an Optical Blood Glucose Measurement for Infrared and Near-infrared Testing.

Signature of Student : .....



Date : March 2015

## ABSTRACT

Yearly, four million people die because of diabetes and it also leads people to other serious disease. Hence, the existence of the portable blood glucose self check device is very helpful to the patients and others who concern to know their blood glucose reading. Non-invasive method is more preferable since it should be painless compared to conventional finger pricking device. Besides, patients who need to do self test often need to refer to the procedures and storing surrounding condition which can be hassle to some people with language restriction. Alternatively, using non-invasive will not be wasteful and the measurement or reading can be done any time and numbers of time. Previously, many researches had been done on non-invasive using near-infrared sensing. From previous research by Sia, he had investigated near-infrared sensing using signal penetrating finger method. However, by using finger penetration, there are no results obtained. He only obtained signal using glucose concentration. Therefore the objectives of this research are to investigate the performance of three different wavelength of sensors; infrared 940nm and infrared 950nm and also near-infrared 1450nm. Sensor that gave the best output had been chosen to achieve the second objective of this project which is to design non-invasive blood glucose measurement device based on optical sensing and to develop prototype of a blood glucose optical sensing instrumentation with acceptable accuracy and repeatability. Generally, the overall system consists of three parts including sensor part, signal conditioning circuit, and also numerical display. The initial design tested by considering initial voltage 1.616V to 1.68V which referred to previous research by Sia as the output of the sensor. Then proceed by using test tube which contains various percentage of glucose concentration. The same methods had been used to the human samples fingers instead of test tube. From the experiment, output graph of the 950nm shows more consistent pattern compared to the 940nm. 950nm also has a larger range scale for voltage which from 5.016V to 5.4633V compare to the 940nm voltage range scale which from 5.0327V to 5.4201V. Further test on human finger had been done by using 950nm infrared but the output voltages were too small. The performance of the measurement can be improved by controlling the surrounding condition and fixed the path length between transmitter and receiver. Test using test tube showed that the near infrared and infrared were capable to predict different glucose concentration. By comparing the performance of infrared and near-infrared, near-infrared gave better performance since near-infrared had higher output voltage range which from 0.6 to 3.4174V compared to infrared. Graph near-infrared output voltage shows that the voltage is almost directly proportional to the percentage of glucose concentrations. By using circuit designed, it can be seen that the voltage reading became higher compared to before meal which shows that there were increment in glucose reading from before to after meal. Therefore, it can be concluded that the circuit design functions accordingly and non-invasively. During human sample test, increment pattern can be seen from fasting to non-fasting condition but the main effect is all samples have different fingers' diameter which each of user needs to be calibrated.

## TABLE OF CONTENTS

	<b>Page</b>
<b>AUTHOR'S DECLARATION</b>	ii
<b>ABSTRACT</b>	iii
<b>ACKNOWLEDGEMENT</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF TABLES</b>	viii
<b>LIST OF FIGURES</b>	x
<b>LIST OF ABBREVIATIONS</b>	xii
<b>LIST OF SYMBOLS</b>	xiii

### **CHAPTER ONE: INTRODUCTION**

1.1 Introduction	1
1.2 Background Of Study	1
1.3 Problem Statement	8
1.4 Objective Of The Study	9
1.5 Significance Of Studies	9
1.6 Scope Of Study	10
1.7 Thesis Outline	10

### **CHAPTER TWO: LITERATURE REVIEW**

2.1 Introduction	11
2.2 Theoretical Of Working Principle	11
2.3 Blood And Glucose	12
2.3.1 Glucose Properties	13
2.4 Classification Of Blood Glucose Measurement	15
2.4.1 Invasive	15

2.4.2	Minimally Invasive	16
2.4.3	Non-Invasive	17
2.4.3.1	Non-Optical Techniques	18
2.4.3.2	Optical Techniques	20
2.5	Current Technologies Of Non-Invasive Blood Glucose Devices	23
2.6	Near-Infrared Spectroscopy And Its Application	25
2.7	Parts And Components	28
2.7.1	Photodiode	28
2.7.2	Signal Conditioning Circuit	29
2.7.3	Microcontroller	31
2.7.4	Output Display	31
2.8	Infrared And Near-Infrared	32

### **CHAPTER THREE: RESEARCH METHODOLOGY**

3.1	Introduction	34
3.2	Flow Chart	35
3.3	Project Design	37
3.3.1	Sensing Part	37
3.3.2	Signal Conditioning Block Diagram	39
3.4	Circuit Construction	39
3.4.1	Simulation Design	40
3.4.2	Hardware Design	46
3.4.3	Software Design	53
3.5	Experiment And Testing	56
3.5.1	Varying Percentage Of Glucose Solution Concentration	57
3.5.2	Human Sample Test	59

### **CHAPTER FOUR: RESULTS AND DISCUSSIONS**

4.1	Introduction	60
4.2	Simulation And Hardware Testing	60
4.3	Hardware Experiment Setup	61
4.3.1	Varying Glucose Concentration	61