View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by UTHM Institutional Repository

DEVELOPMENT OF A PC INTERFACED BLOOD PRESSURE METER (E-BPMS)

IDA LAILA BINTI AHMAD

UNIVERSITI TEKNOLOGI MALAYSIA

PERPUSTAKAAN UTHM
30000001957492

PSZ 19:16 (Pind. 1/97)

UNIVERSITI TEKNOLOGI MALAYSIA

BORANG PENGESAHAN STATUS TESIS◆

JUDUL: DEVELOPMENT OF A PC INTERFACED BLOOD PRESSURE METER (e-BPMS)

SESI PENGAJIAN: 2005/2006

Saya IDA LAILA BINTI AHMAD

(HURUF BESAR)

mengaku membenarkan tesis (~~PSM~~/Sarjana/~~Doktor Falsafah~~)* ini disimpan di Perpustakaan Universiti Teknologi Malaysia dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Teknologi Malaysia.
2. Perpustakaan Universiti Teknologi Malaysia dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. * * Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	TIDAK TERHAD	

(TANDATANGAN PENULIS)

Alamat tetap:
146, TAMAN SRI INDAH
JALAN LENCONG BARAT,
05050 KEDAH DARUL AMAN

Tarikh: MEI 2006

Disahkan oleh

(TANDATANGAN PENYELIA)

PROF. DR RUZAIRI ABDUL RAHIM

Nama Penyelia

Tarikh: MEI 2006

CATATAN:
* Potong yang tidak berkenaan.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.
◆ Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

"I/~~We~~* hereby declare that I/~~we~~* have read through this project report and in my/~~our~~* opinion this project report is sufficient in terms of scope and quality for the award of the degree of Master of Engineering (Electrical-Electronics & Telecommunications)"

Signature	:	.....
Supervisor	:	Prof. Dr. Ruzairi Bin ~~Hj.~~ Abdul Rahim
Date	:	May 2006

* *Delete as necessary*

DEVELOPMENT OF A PC INTERFACED BLOOD PRESSURE METER (e-BPMS)

IDA LAILA BINTI AHMAD

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical-Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MAY 2006

I declare that my project report entitled "*Development of a PC Based Blood Pressure Meter (e-BPMS)*" is the result of my own research except as cited in references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	.....
Name	:	Ida Laila binti Ahmad
Date	:	May 2006

To my beloved parents; Encik Ahmad Bin Shapii and Puan Aslinah Masran, thanks for encouragement and never ending support.

My dearest sisters; Ida Liyani and Ida Farhana Afiqah credits go to both of you for all the joyous moments.

And for my great hearted fiancé; Redzuan Shah Bin Yussoff, my deepest appreciation for your great advise, constant sacrifice and endless understanding.

May Allah (swt) shower his blessings upon all of you

ACKNOWLEDGEMENT

Alhamdulillah, in completion of this project report I would like to express my credit to all persons who involved either directly or indirectly in giving useful inputs to me.

Firstly, my highest gratitude to my supervisor Prof. Dr. Ruzairi Bin Abdul Rahim for his beneficial ideas, wonderful guidance and encouragement. Without him, this project would not be a success.

Secondly, I took this opportunity to thanks my sponsor Jabatan Perkhidmatan Awam (JPA) and Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO) for funding me to further my studies.

Lastly, to all my colleagues, course mates and other graduate students, thanks for all the moral support and encouragement throughout my entire study in UTM.

ABSTRACT

Blood pressure meter is an essential instrument to determine our blood pressure status. Nowadays, there are various types of blood pressure meter available manufactured from various companies. In order to meet the demand on telemedicine and technology advancement, a new form of blood pressure meter is desirable. This prototype of blood pressure meter is interfaced with a personal computer (PC) which able to simulate the measurement process in real time. The proposed system was named e-BPMS (Electronic Blood Pressure Measurement System) suggests the usage of both hardware and software in determining blood pressure reading. Hardware elements operate on oscillometric principle which gives the results in terms of systolic, diastolic and MAP (Mean Arterial Pressure). Furthermore, these results will be presented and simulated on the software end. e-BPMS graphical user interface (GUI) was developed by using Visual Basic 6.0 (VB6) language which highlights the user friendly attributes. Moreover, the simulated waveform will evaluate the blood pressure and gives beneficial advises in term of controlling blood pressure to be optimal. This application shows significant improvement on the overall performance and gives reliable results. The framework used to design e-BPMS is easy to understand and it can be extended further to endorse new application area.

ABSTRAK

Alat mengukur tekanan darah adalah penting untuk memberikan status kesihatan tekanan darah seseorang individu. Kini, terdapat pelbagai jenis alat mengukur tekanan darah yang beroperasi menggunakan teknik-teknik yang berlainan dikilangkan oleh pelbagai pengeluar. . Kepesatan perkembangan teknologi pada masa ini untuk mencapai aplikasi Tele-Perubatan menyebabkan keperluan untuk mencipta satu alat mengukur tekanan darah yang baru meningkat. Projek ini bertujuan untuk mencadangkan satu alat mengukur tekanan darah yang baru menggunakan prinsip osilometrik di mana ianya dihubungkan dengan komputer peribadi dan boleh mamaparkan simulasi bagaimana tekanan darah seseorang ditentukan. Prototaip alat mengukur tekanan darah ini dinamakan e-BPMS iaitu singkatan untuk "Sistem mengukur tekanan darah elektronik". Sistem ini boleh dibahagikan kepada dua elemen iaitu "hardware" dan juga "software". "Hardware" akan memberikan keputusan analisis dalam bentuk bacaan sistolik, diastolik dan juga purata tekanan arteri. Seterusnya bacaan ini akan dipaparkan oleh "software" yang telah diprogramkan menggunakan bahasa pengaturcaraan "Visual Basic 6.0" (VB6) pada komputer. Hasil prototaip ini berjaya memberi keputusan yang tepat dan berjaya memenuhi objektif projek ini dan ianya boleh diperbaiki lagi di masa akan datang.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF SYMBOLS / ABBREVIATIONS	xv
	LIST OF APPENDICES	xvii
1	**INTRODUCTION**	
	1.1 Background	1
	1.2 Theory	2
	1.2.1 Blood Pressure	2
	1.2.2 Factors contributing to blood pressure diseases	3
	1.2.3 Blood Pressure Instruments	5
	1.3 Blood Pressure Measurements Methods	6
	1.3.1 Auscultatory Techniuqe	6
	1.3.2 Automated Auscultatory technique	7
	1.3.3 Oscillometric technique	7

	1.3.4	Infrasound and ultrasound technique	8
	1.3.5	Tonometry technique	9
	1.3.6	Ambulatory blood pressure monitoring technique (ABPM)	9
	1.3.7	Pulse dynamic technique	10
	1.3.8	Plethysmography technique	10
	1.3.9	Finger cuff technique	10
1.4		Statement of the problem	11
1.5		Project Objectives	11
1.6		Significance of project	12
2	**LITERATURE REVIEW**		
2.1		Review of related literature	13
3	**METHODOLOGY**		
3.1		Method chosen	25
3.2		Instruments	26
	3.2.1	Hardware	27
	3.2.2	Software	29
	3.2.3	System Integration	31
4	**HARDWARE DEVELOPMENT**		
4.1		Hardware Design	32
4.2		Hardware Parts	33
	4.2.1	Pressure sensor (MX5050GP)	33
	4.2.2	Operational amplifier (LM324N)	35
	4.2.3	Differential amplifier	36
	4.2.4	Two poles high pass resistance-capacitance (RC) filter	37
	4.2.5	PIC 16F877	38
	4.2.6	MAX232	41
	4.2.7	RS 232 Serial interface	43
4.3		Handshaking in Serial Communication	46

	4.3.1	Software Handshaking	47
	4.3.2	Hardware Handshaking	48
4.4	Full circuit operation		48
4.5	Hardware Testing		49
	4.5.1	Alpha Testing	49
	4.5.2	System Testing	49
5	**SOFTWARE DEVELOPMENT**		
5.1	Software Design		50
5.2	Graphical User Interface Design		50
	5.2.1	Flash Screen	51
	5.2.2	Main Screen	51
	5.2.3	e-BPMS File Menu	53
	5.2.4	e-BPMS View Menu	55
	5.2.5	Measurement Interface	56
	5.2.6	Error Indication	58
5.3	PIC Programming		58
5.4	Waveform Reconstruction Algorithm		63
6	**RESULTS AND DISCUSSIONS**		
6.1	Hardware Experiments		64
	6.1.1	Pressure sensor	64
	6.1.2	Differential Amplifier	66
	6.1.3	Two poles high pass RC filter	67
	6.1.4	PIC16F877 microcontroller	69
	6.1.5	MAX232-RS232 interface	70
	6.1.6	e-BPMs output (blood pressure reading determination)	71
6.2	Software Simulation		73
	6.2.1	Waveform Reconstruction	73
	6.2.2	Comparison of Results	74
6.3	Performance Measures		75

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions 77

7.2 Limitations of e-BPMS 78

7.3 Future recommendation 79

REFERENCES 81

APPENDICES 85

LIST OF TABLES

TABLE	TITLE	PAGE
1.1	Blood pressure classification for adults given by AHA	3
5.1	Baud Rates for Asynchronous Mode (BRGH = 1)	60

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Sphygmomanometer	5
1.2	Determination of blood pressure using oscillometric technique	8
2.1	OMRON blood pressure meter	19
2.2	CITIZEN blood pressure meter	20
2.3	BIPITONE blood pressure meter	20
2.4	HEALTH-O-METER blood pressure meter	21
2.5	LUMISCOPE blood pressure meter	22
2.6	FORECARE blood pressure meter	23
3.1	Basic principle in oscillometric method	26
3.2	Block diagram for e-BPMS	27
3.3	Hardware flowchart	28
3.4	Software flowchart	30
4.1	MPX5050GP pressure sensor	33
4.2	Expected output of pressure sensor	34
4.3	Power supply decoupling and filtering circuit	34
4.4	LM324N operational amplifier	35
4.5	Differential amplifier circuit	37
4.6	Expected oscillation signal given by differential amplifier	37
4.7	Expected filter frequency response	38
4.8	Basic microcontroller block diagram and PIC16F877 pin assignments	39

4.9	Test set up for MAX232	42
4.10	Expected output from MAX232	42
4.11	MAX232 chip configuration and its internal outlook	43
4.12	Bi-directional RS-232 interface	44
4.13	Handshaking timing diagram	47
5.1	Flash screen	51
5.2	e-BPMS main screen	52
5.3	Text document of "Info" button	52
5.4	e-BPMS waveform display screen	53
5.5	e-BPMS file menu	54
5.6	Example of result to be printed	54
5.7	e-BPMS "about" screenshot	55
5.8	e-BPMS database screenshot	56
5.9	e-BPMS patient blood pressure status display	57
5.10	Sample of waveform reconstructed by e-BPMS	57
5.11	e-BPMS error indication	58
5.12	Initialization of register ADCON1 and all ports used	59
5.13	Setting of transmission mode and baud rate	60
5.14	PC detection of START/STOP data transfer	61
5.15	Starting the Analog-to-Digital Conversion Operation	61
5.16	ADRESL and ADRESH setting for data transfer	62
5.17	Detect the end of Capture Duration	62
5.18	Routine for reconstruction of waveform	63
6.1	Differential pressure obtained from sensor	65
6.2	Differential amplifier circuit	67
6.3	Filter frequency response	68
6.4	Input / output of analog to digital converter (ADC)	69
6.5	Output of both pin T2IN and T2OUT	71
6.6	Example of blood pressure waveform obtained	72
6.7	Blood pressure oscillations envelope	73
6.8	Waveform reconstruction points	74

6.9	Comparison on waveforms obtained from e-BPMS	75
6.10	Performance measures of e-BPMS	76
7.1	Unwanted notch and jitters captured	78
7.2	Inconsistent reading when pressure > 150mmHg is applied	79

LIST OF SYMBOLS/ ABBREVIATIONS

A/D	-	Analog-Digital
AAMI	-	Association of Advancement Medical Instrumentation
ABPM	-	Ambulatory Blood Pressure Monitoring
ADC	-	Analog to digital Converter
AHA	-	American Health Association
A_p	-	Attenuation
ASCII	-	American Standard Code for Information Interchange
atm	-	Atmospheric unit (pressure measurement)
CMOS	-	Complementary MOSFET
COM	-	Component Object Model
CP	-	Cuff Pressure signal
CPU	-	Central Processing Unit
CTS	-	Clear To Send
DIY	-	Do It Yourself
DSR	-	Data Set Ready
DTR	-	Data Terminal Ready
e-BPMS	-	Electronic Blood Pressure Measurement System
EIA/TIA-232E		Serial Communication Standard
EMI	-	Electromagnetic Induced Voltage
FET	-	Field Effect Transistor
GND	-	Ground
GPIB	-	General Purpose Interface Bus
GUI	-	Graphical User Interface
Hz	-	Hertz (unit of frequency)
LCD	-	Liquid Crystal Display

MAP	-	Mean Arterial Pressure
mmHg	-	Unit millimeter mercury
MOSFET	-	Metal Oxide Semiconductor FET
MS Chart	-	Microsoft Chart (ActiveX function)
MS Comm.	-	Microsoft Communication (ActiveX function)
MSC	-	Multimedia Super Corridor
NIBP	-	Non Invasive Blood Pressure
Pa	-	Pascal unit (pressure measurement)
PC	-	Personal Computer
PIC	-	Peripheral Interface Controller
RC	-	Resistor-Capacitor
RS-232	-	Serial Communication Protocol
RTS	-	Request to Send
R_{XD}	-	Received data
SI	-	International System (unit of measurement)
SPBRG	-	Baud rate generator
TTL	-	Transistor-Transistor Logic
T_{XD}	-	Transmit data
UART	-	Universal Asynchronous Receiver/Transmitter
V	-	Volt (unit of voltage)
VB6	-	Visual Basic 6.0
V_{DC}	-	Direct current Voltage
V_{out}	-	Voltage output
V_s	-	Voltage Supply
WHO	-	World Health Organization

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	PIC Programming	85
B	VB Programming	88
C	e-BPMS Circuit Diagram	92
D	Standard Blood Pressure Table	93
E	Data Sheet	94

CHAPTER 1

INTRODUCTION

1.1 Background

Blood pressure is one of most important measurements which indicate person's health condition. Abnormal blood pressure reading may lead to various diseases which can be prevented by treatment. Blood pressure related diseases are usually being referred as "silent killer". The consequence promoted can be either cardiac disorder or the malfunctions of our body systems. Considering these huge effects may be too harmful for human body, thus preventive action needs to be taken. High blood pressure is an epidemic disease which always a major concerns in developed countries. Statistic shows the great number of cases for the past decades, which triggers the insight to prevent and control this disease rather than cure it. Nowadays, the need for a reliable medical technologies and analysis is desirable, since the users prefer to experience their medical diagnosis themselves. Home monitoring provides an accurate record of measurements over time helps in planning an overall personal health regimen. Furthermore, blood pressure management is a step towards a healthier lifestyle.

1.2 Theory

1.2.1 Blood pressure

Blood pressure is defined as the pressure of the blood against the walls of the arteries. It is the resultant of two forces. One is created by the heart as it pumps blood into the arteries and through the circulatory system. The other is the force of the arteries as they resist the blood flow. Blood pressure is measured in millimeters of mercury (mmHg) and recorded as two numbers systolic pressure "over" diastolic pressure. For example, the doctor might say "130 over 80" 130/80 mmHg as a blood pressure reading. The measurement is taken when the doctor puts the cuff around patient's arm and pumps it up.

The pressure exerted by the cuff will block the blood flow in the vessel. As the pressure is released slowly, blood starts to flow again and the doctor can hear the flow using a stethoscope. The number at which blood starts flowing again is recorded as maximum output of pressure of the heart (systolic). Then, the doctor will continue releasing the pressure of the cuff and listens until there is no sound. The number (80) indicates the pressure in the system when the heart is relaxed (diastolic).

According to American Heart Association (AHA), optimal blood pressure with respect to cardiovascular risk is less than 120/80 mmHg. However, unusually low readings should be evaluated to rule out medical causes. If the patient exhibits low readings every measurements, there is a potential of having low blood pressure (hypotension). The systolic pressure of 120 to 139 mmHg or diastolic pressure of 80 to

89 mmHg is considered as at risk of having high blood pressure (pre hypertension). Furthermore, blood pressure reading of 140/90 mmHg is considered elevated high (hypertension). The range of blood pressure recommended by AHA is summarized in the Table 1.1 below.

Table 1.1: Blood pressure classification for adults given by AHA

Category	Systolic (mmHg)	Diastolic (mmHg)
Normal	< 130	<85
High Normal	130-139	85-89
Hypertension		
Stage 1 (mild)	140-159	90-99
Stage 2 (moderate)	160-179	100-109
Stage 3 (severe)	108-209	110-119
Stage 4 (very severe)	≥210	≥120

Blood pressure reading is known to be varied between one people to another. It is recommended by AHA that ideally, blood pressure must be checked at least twice a year and it should be more often if it is high. Some of the factors affecting blood pressure can be classified into several categories concerning physiological, gender, lifestyles and many others. The elaboration of these factors will be in following section.

1.2.2 Factors contributing to blood pressure diseases

Firstly is the elasticity of blood vessel determines the amount of blood flow at one time. The nature of blood vessel changes as we age, as the vessel gets thicker, the