

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

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*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.*

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appreciation for your great advise, constant sacrifice and endless
understanding.*

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



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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. . Kepsatan 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.

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LIST OF SYMBOLS/ ABBREVIATIONS

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

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

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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 person 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

capability of blood vessel to absorb is diminishes with time. These causes the older people are more likely to experience hypertension. Some people also may suffer low blood pressure (hypotension) due to low blood volume in their body system.

Generally, high blood pressure is related to high salt intake in our food consumption. Since people nowadays are exposed to busy life routines made them consuming bad diet habit which eventually promotes obesity (overweight). Other than that, cigarette smoking and alcohol intake may also contribute to this problem. Lack of exercise of people nowadays also contributes to high blood pressure.

Female are proven has higher rate of hypertension cases compared to male. Research done proposed that, women who experience pregnancy, menopause and overweight are at high risk of hypertension. This is due to the fact that, instable blood pressure may be resulted from the above situations, since women will experience hormonal changes.

Some people who have the history of high blood pressure in their families also have been identified to be one of the hypertension reasons. Other than that, people who are on medication or under doctor's prescription may observe irregularities in their blood pressure. This may be resulted from the drugs (prescriptions) they are taking. Certain hormones, like adrenaline which is released when people under stress may also cause certain blood vessels to constrict, and this raises the blood pressure. If people are exposed to constant stress, it means that the heart has to work too hard and this increase the blood pressure reading.

1.2.3 Blood pressure instrument

Traditionally, a sphygmomanometer is used for measuring blood pressure in the arteries. The word is derived from the Greek “sphygmus” (pulse), plus the scientific term manometer was introduced by Scipione Riva Rocci, an Italian Physician during 1896. Usually it consists of an inflatable cuff, a measuring unit and also a tube whereby, the inflation bulb is used along with stethoscope. The image of sphygmomanometer is given in Figure 1.1.

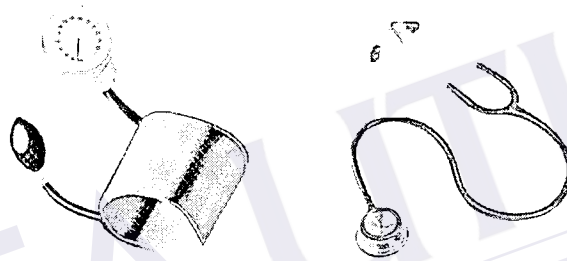


Figure 1.1 Sphygmomanometer

Due to technologies advancement, blood pressure testing devices now are using electronic instruments or digital readouts. In these cases, the blood pressure reading appears on a small screen or is signaled in beeps, and no stethoscope is used. Most of digital instruments have an automatic inflation mechanism, which replace the manual inflation bulb for simplicity and comfort. A digital system is widely known for its convenience and robustness even in noisy environment is preferable. Therefore, blood pressure meter now available is still adapting the same measuring techniques with added features. Some of available blood pressure meter are table-top, wristband and also finger. Considerations need to be made when designing a digital blood pressure meter since electronic devices are very susceptible to operating temperature and also humidity.

1.3 Blood pressure measurement methods

There are few available techniques employed for blood pressure measurements in which have their own strengths and weaknesses. Two popular approaches can be classified into two major groups known as invasive and non-invasive methods. As the name implies, invasive method involve catheterization (cut) where the patient need to undergone a minor surgical process. On the other hand, the non invasive technique offers simplicity, convenience, and comfort procedure to the patient is more preferable.

The invasive method is undoubtedly yields the most accurate measurements, but it is rarely used since it is more risky and patient may suffer excessive blood loss. Even today, invasive catheterization procedures are seldom used due to the risk of infection. Although, non invasive sacrifice a degree of accuracy in the measurement, the procedures which are considering for patient safety are widely applied. Two major methods for non invasive measurement are known as Auscultatory and Oscillometric. In fact, there are various methods used for measuring blood pressure which will be discussed next.

1.3.1 Auscultatory technique

This technique based on the ability of the human ear (expert practitioner) to detect and distinguished sounds. It was suggested by Korotkoff during 1905 has yet became the most common method of blood pressure measurement today. The clinician will use a stethoscope to listen for the Korotkoff sounds as the cuff deflates to determine the systolic, diastolic and estimate mean arterial pressure reading. The great advantage

is clinician is allows to determine the quality of each measurement. However, the possible error may arise due to differences in hearing acuity from one clinician to another. Furthermore, the unqualified or inexperienced clinician may not be immune to outside noise and other interference, thus assessing inconsistent Korotkoff sounds during measurement.

1.3.2 Automated Auscultatory technique

This particular technique was developed to replace to function of human ear by using microphone. A sound based algorithm was applied to estimate the systolic and diastolic readings. The drawback of this technique is lack of validation ability. In addition to noise artifact sensitivity, the algorithm may not adequately compensate for patient suffer low blood pressure (hypotension). Hence, the oscillometric technique was proposed to make the automated measurement more reliable.

1.3.3 Oscillometric technique

The name implies the procedure is done by measuring the oscillations caused by the arterial pressure pulse. These oscillations are the results of the coupling of the occlusive cuff to the artery. Oscillometric devices measure the mean but estimate both systolic and diastolic as proposed in Figure 1.2. The point of maximum amplitude is considered mean arterial pressure (MAP). Device using this technique do not use microphone, hence it is not affected by cuff placement and external noise. On the other

hand, since it does not allow measurement validation, it is sensitive to patient movement. Error due to this technique may be generated from inaccurate determination of MAP.

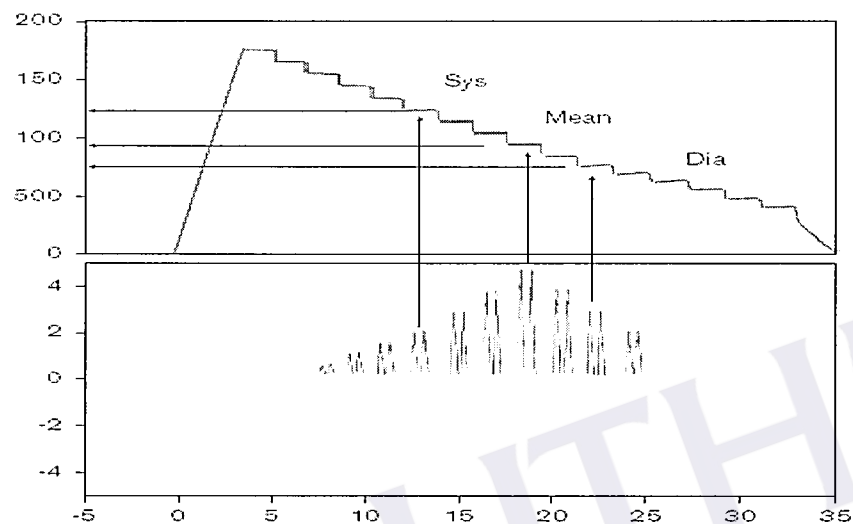


Figure 1.2 Determination of blood pressure using oscillometric technique

1.3.4 Infrasonic and ultrasound technique

Infrasonic technique attempts to improve on the auscultatory method by detecting the low frequency Korotkoff sound vibrations below 50 Hz, in which including sub audible vibrations. On the other hand, ultrasound technique is not commonly used for measuring blood pressure. Usually, it is use in combination with other methods. Major feature of this method is, the values recorded by using ultrasound can be very operator dependent.

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