University of Southern Queensland
Faculty of Engineering and Surveying

Develop a system to Monitor, Analyse and Report health data captured during exercise

A dissertation submitted by

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Abstract

This dissertation documents the design, develop and testing of the system to Monitor, Analyse and Report health data captured during exercise. The system targeted for home user and has been customized for single user.

Before developing of the system, a research is carried to understand the cardiovascular disease, cardiovascular system and the parameters of the cardiovascular system and equipment used to measure.

During the development of the system, research is also conducted on the signal analyses, circuit design and programming technique.

A prototype of the circuits is developed and tested but the developing of the microcontroller is halted due to the extensive requirement of time and the difficulty in the programming. The program for user interface and presentation of the result is developed with features that simulated the possible situation of a successful transmission between the equipment and the computer through the interface circuit. Work is currently underway to improve the system.

The results of the tests undertaken so far indicate that the system required only further development of the microcontroller and the signal processing circuit.

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Limitations of Use

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusion set out in this dissertation are entirely own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Student Number: D10349257

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Signature

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Date

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Chapter 1

Introduction

1.1 Introduction

This chapter provides a brief introduction of the project. It also includes the objectives of the project and description of the content of this dissertation.

1.2 Project Aim

Health information is critical to the doctor in providing the best possible treatment to the patient and it helps increase the awareness of the patient to one's health condition. This project aims to develop a system to Monitor, Analyse and Report health data captured during exercise. A research is carried out to access current health of Australian in particular and provides some suitable methods of measuring the health indicators. Lastly, develop a system to monitor, analyses and report these health data. The project only focuses on the blood pressure and pulse to increase awareness against cardiovascular disease.

1.3 Project overview

The product of the project involves the equipment that is used to measure the blood pressure and pulse, the interface circuit that is used to establish the communication between the equipment, the circuit and the computer and the development of the program to interpret the information from the equipment.

1.4 Project Objectives

The project is categorised into six main objectives and two supplement objectives. These six main objectives are required to fulfil the project requirements, whereas the two supplement objectives will help to enhance the project.

1.4.1 Main objectives

1. Define the objective and tasks of the project

The first task of the project is to plan the possible outcome of the project. Identify the objectives of the project and list the tasks required to achieve the objectives.

2. State the Requirement, Restriction and Resources of Project

After the tasks are listed, it requires a rough plan to identify the requirements, restriction and resources that are needed to fulfil the objectives.

3. Research the critical parameters, measuring device types and current devices on the market.

The initial plan of the task with requirements and resources listed is only a conception view of the project. Some information gathering process must be on the way to provide more insight of the project. This includes the understanding of the indicators of health, the equipment used to measure these health indicators and the equipment that is on the market.

4. Investigate the interface of the equipment

Then a next step is taken to investigate the interface method and requirement of the equipment and computer.

5. Design several possible interface circuit and select the most suitable for the project

The development of the interface circuit will have to undergo different possibility of different possible plan. Then the appropriate plan is selection for the project.

6. Develop and test the interface and software between the equipment and the computer

Develop the interface circuit that required for the communication between the equipment and the computer.

1.4.2 Additional objectives

7. Evaluate the design and minor improvement to the system

The system is not perfect and required to have another review to improve it.

8. Incorporate other devices to the system

Many other devices can be interface to the system to increase the functionality or user friendliness.

1.5 Overview of Dissertation

This dissertation is a documentation of the work involved in the development of this project. It is to provide adequate information of the project for future development. The project is classified into the “research” and “development”. The “research” involves the required information for the project. This includes:

1. The background of the project in chapter 2
2. The Methodology of the project in chapter 3
3. The equipment in chapter 4
4. The interface circuit in chapter 5
5. The program in chapter 6

1.6 Conclusion

This chapter describes the overview of the project which includes the project title, aim and objectives and also provides a brief introduction of the expectation of this dissertation. To achieve the objectives stated, a good understanding of the project background is required. The next chapter will explain the background of the project.

Chapter 2

Background

2.1 Introduction

“Early detection of serious disease is a key priority in preventative health services” is one of the objectives of the department of Health and Aging of Australia (Chief Medical officer’s report, 1999-2000). This project provides the same intention in promoting early detection of cardiovascular disease. This chapter explains how cardiovascular disease affects Australian both socially and economically and the function and components of cardiovascular system.

2.2 Cardiovascular disease and the cardiovascular System

The cardiovascular disease is disease that affects the normal functional operation of the cardiovascular system. The function and structure of the cardiovascular system and its components will be detailed in section 2.4 and 2.5.

2.3 Cardiovascular disease

Cardiovascular disease is the most important item in the national health profile. The number of Australians affected by cardiovascular disease have increased from 1 in every 6 to 1 in every 4 which is about 67% of families suffer cardiovascular disease (Heart disease and stroke statistics, 2005 update). Above all, 38% of death is caused by cardiovascular disease. In 2004, 50,292 people died due to cardiovascular disease. In every 10 minutes, an Australian dies due to cardiovascular disease. These figures illustrate how serious the cardiovascular disease is affecting Australia.

2.3.1 Cost of cardiovascular disease on Australia economy

Health problem is the heavy burden to most developed countries including Australian. Large sum of money has been poured to the medical sector to sustain the health of Australians. In the overall budget of health benefit, the cost to counter disease affecting the cardiovascular system is always high. In 2004, the direct health system costs related to cardiovascular disease was estimated at $7.6 billion (11% of total health spending) (Heart disease and stroke statistics, 2005 update). It is expected to reach $11.5 billion by 2011. Table 2.1 shows a brief summary of the direct cost of cardiovascular disease affecting the health system.

Items	Cost (million)
Hospital inpatient	$2700
Pharmaceuticals	$1700
Residential aged care	$639
Others	$2561
Total	$7600

(Heart disease and stroke statistics, 2005 update)

Table 2.1 The direct cost of cardiovascular disease affecting the health system

This does not include the indirect spending which is estimated to be $6.6 billion in 2004. There are 55,871 Australians who could not work due to cardiovascular disease. Production losses due to lower employment rates and premature mortality have reached a total of $3.6 billion.

2.3.2 Types of cardiovascular disease and its impact on Australia

Before the discussion of the cardiovascular system (detailed in 2.3), this section introduces some cardiovascular disease. This includes some common types of cardiovascular disease and facts and figures showing how these cardiovascular diseases are affecting the lives and economy of Australia.

Some common types of cardiovascular disease include:

- Hypertension

Hypertension is also known as high blood pressure. High blood pressure is caused by the constriction of the arterioles. When the arterioles are constricted, it causes the heart to work harder than normal. Over a period of time, it causes injury to the heart and the arteries. Injured heart and arteries increase the risk of heart attack, heart failure and stroke.

- Tachycardia

Tachycardia is rapid beating of the heart. Rapid beating of the heart reduces the heart's ability to pump and circulate blood effectively. It cause dizziness, light headedness and fainting or near fainting.

- Arrhythmias

Arrhythmias are abnormal heart rhyme and it causes the heart to pump less effectively. When the heart is less effective, it causes from barely perceptible to cardiovascular collapse and death.

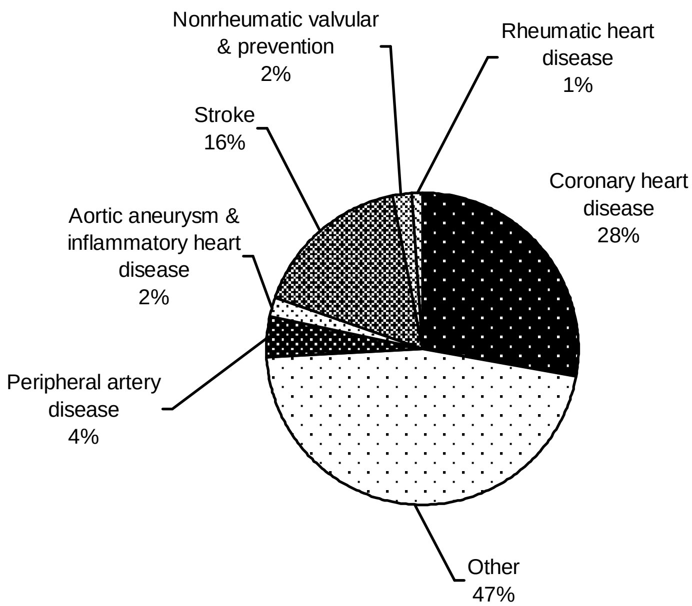
(Heart and stroke facts, American Heart Association, 1992-2003)

Table 2.2 provides the number and percentage of people affected by different types of cardiovascular diseases. The pie chart in figure 2.1 shows the distribution of health cost ($6,563.7m) due to cardiovascular disease. These facts and figures in the table and chart illustrated how serious the cardiovascular diseases affect Australian and the purpose of the project it to reduce figures by provide aids to early detection of cardiovascular disease which will greatly reduce the cost and increase the recovery of Australians.

Cardiovascular disorder (long term)	males ('000)	% male pop'n	females ('000)	% female pop'n	people ('000)	% total pop'n
Hypertension	868.9	9.0%	1,040.3	10.6%	1,909.1	9.8%
Angina	137.6	1.4%	122.8	1.3%	260.3	1.3%
Other coronary heart disease	79.6	0.8%	46.1	0.5%	125.6	0.6%
Other heart disease	6.0	0.1%	6.4	0.1%	12.4	0.1%
Tachycardia	143.4	1.5%	195.0	2.0%	338.4	1.7%
Oedema	88.3	0.9%	208.3	2.1%	296.6	1.5%
Diseases of arteries, arterioles & capillaries	124.8	1.3%	74.4	0.8%	199.1	1.0%
Haemorrhoids	88.8	0.9%	119.8	1.2%	208.6	1.1%
Varicose veins	97.8	1.0%	341.9	3.5%	439.7	2.3%
Other CVDs	93.8	1.0%	111.3	1.1%	205.1	1.1%
Cardiac murmurs and sounds	159.3	1.7%	206.2	2.1%	365.4	1.9%
Other CV signs & symptoms	24.7	0.3%	41.6	0.4%	66.2	0.3%
Total	1,387.4	14.4%	1,798.4	18.4%	3,185.9	16.4%

Source: Access Economics derived from ABS (2002), Table 5. Self-reported data.

Table 2.2 The population affected by different type of cardiovascular disease



Source: Access Economics derived from ABS (2002)

Figure 2.1 The distribution of health cost due to cardiovascular disease

2.3.3 Symptoms of Heart Disease

The symptom of cardiovascular diseases depends on the type of disease. For instance, the warning signs for heart attack are:

- Chest discomfort

Chest discomfort refers to discomfort in the centre of the chest that lasts more than a few minutes or that goes away and comes back. These discomforts might be uncomfortable pressure, squeezing, fullness or pain.

- Discomfort or pain in other areas of the upper body

The upper body usually refers to one or both arms, the back, neck jaw or even stomach.

- Shortage of breath

Shortage of breath usually happens before chest discomfort.

- Other warning signs

These may includes breaking out in cold sweat, nausea or light-headedness.

(Heart and stroke facts, American Heart Association)

The warning signs for stroke are:

- Sudden numbness or weakness of the face, arm or leg
- Sudden confusion
- Suddenly having difficulty in
    - Speaking or understanding
    - Seeing in one or both eyes
    - Walking
    - Dizziness
    - Loss of balance
- Sudden headache with unknown cause

(Heart and stroke facts, American Heart Association)

The symptom of cardiovascular disease is usually not a preferred approach as most symptoms of cardiovascular disease only develop in the late stage of cardiovascular disease.

2.4 Function of cardiovascular system

The human body is the integration of several systems but these systems can also operate independently. The cardiovascular system is the most important system in the human body because the cardiovascular system is directly related to all systems in the body. The role of the cardiovascular system is classified in five categories:

- Delivery

The cardiovascular system delivers oxygen.

- Removal

The cardiovascular system removes carbon dioxide.

- Transport

The cardiovascular system helps to transport hormones from glands to receptors

- Maintenance

The cardiovascular system regulates the temperature and pH level of the body

- Prevention

The blood in the cardiovascular system prevents dehydration and infection

(Physiology of sport and exercise, 2003)

2.5 Structure of cardiovascular system

The cardiovascular system consists of three main components:

- Heart
- Blood vessels
- Blood

(Mayo Clinic heart book, 1993)

With these three components, the cardiovascular system acts as a circulation system, with the heart as the pump, the blood vessels as the pipe and the blood as the transport medium (Exercise physiology, third edition).

2.5.1 Heart

The heart is divided into four chambers. Two atria are receiving chambers for blood returning from the arteries and two ventricles are delivery chambers that pump blood into the blood vessels. The rate of the flow of blood is controlled by the values in the heart and the rate the heart beat. These values also help to prevent a reverse flow of blood hence the blood flow is maintained in unidirectional (Clinical Cardiology, sixth edition).

2.5.2 Blood vessels

The blood vessels are like roads in a transportation system. The vessels are linked with all cells in the body which create paths for the blood to travel. These vessels are made up of veins, arteries and capillaries. Blood are delivered through the arteries to the capillaries and from the capillaries to the veins back to the heart. All exchange of oxygen, carbon dioxide and nutrients happen in the capillaries (Physiology of sport and exercise, 2003).

2.5.3 Blood

The blood is the medium of transportation. It carries substances like oxygen to the respective cells and carries carbon dioxide back to the heart. Blood also helps carry waste material to other organs like kidney and liver (Clinical Cardiology, sixth edition).

2.6 Conclusion

This chapter illustrated how the cardiovascular disease affects the economy and population of Australia, the function of cardiovascular system and its components. The purpose of the project targets to reduce the impact of cardiovascular disease through continuous monitoring of health condition. The next chapter will illustrate the approach of the project to achieve this target.

Chapter 3

Methodology

3.1 Introduction

This chapter will highlight the two approaches in developing the system and the methods that can be used to achieve the approach. Using the method, the project required the understanding of the equipment used to measure the parameters of the cardiovascular system. The chapter will also include the selection of the parameters of the cardiovascular system and the equipment used to measure these parameters.

3.2 Approach of the project

There are two approaches to early detect of cardiovascular disease, the symptoms of cardiovascular disease and continuous monitoring of cardiovascular system. The symptom of the cardiovascular diseases is discussed in section 2.3.3.

3.2.1 Continuous monitoring of cardiovascular system

Continuous monitoring of the cardiovascular system refers to the use of medical equipment to measure the critical parameters of the cardiovascular system. This approach is preferred for the detection of cardiovascular disease in the early stage. It helps to greatly reduce the medical treatment cost and increase the chances of recovery.

3.3 Methodology

In an engineering point of view, there are three ways to improve continuous monitoring of cardiovascular system:

- The instrument that measure the parameter

  This method improves the accuracy of the instrument.

- The method of measuring the parameter

  This method improves the way of measuring of the parameter to achieve more accurate measurement or reduce the error during measuring.

- The system of measuring the parameter

  This method improves the presentation of the value of the parameter.

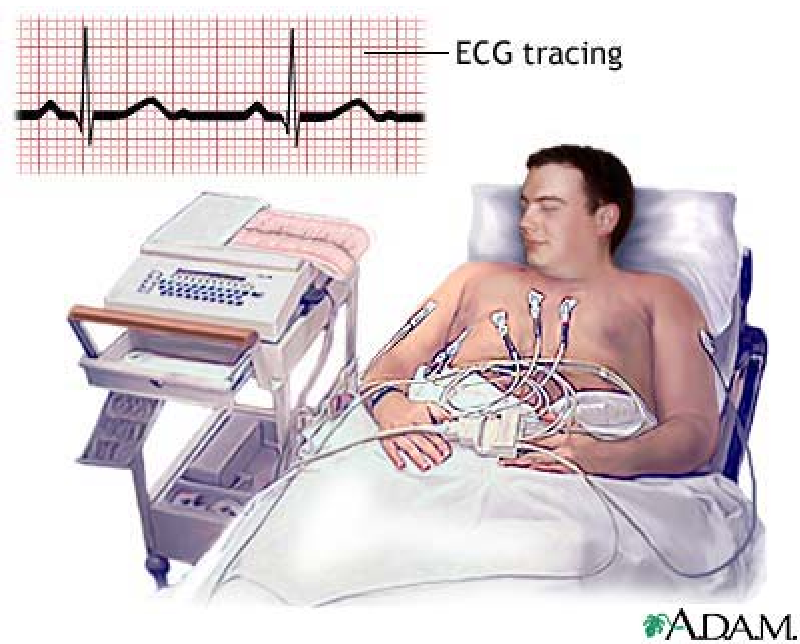
This project targets to improve the system of measuring the parameters of cardiovascular system. To achieve this, this project will develop a system to measure, analyses, interpret and present the value of these parameters. This aids doctors and user in understanding the health of the user.

3.4 Parameters of the cardiovascular system

The health condition of the body is directly related to the performance of the cardiovascular system. Hence, it is the measurement of the performance of the three components in the cardiovascular system.

3.4.1 Measurement of the heart performance

The parameters for the heart are the heart rate and the heart rhythm (Exercise physiology, third edition). Heart rate is the measurement of the rate the heart pumps also known as heart beat. This can be achieved by using a heart rate meter. Heart rhythm is the frequency which the heart beats and requires an electrocardiogram (ECG) machine to measure the oscillation of the heart.



(Picture taken from http://health.allrefer.com)

Figure 3.1 Picture of ECG

This oscillation is created by the potential difference of the muscles of the heart. Usually five electrodes are placed on the body to measure the pacemaker also known as sinoatrial (SA). The sinoatrial are a group of cells which act like switches that spontaneously generate action potential at a constant rate. Depending on the position of the electrodes, the potential difference can be calculated by the ECG machine and create a waveform of the frequency of the heart (Biomedical instrumentation, Second edition).

3.4.2 Measurement of the blood vessels

The parameters for the blood vessels are the blood pressure, blood volume, stroke volume and pulse (Exercise physiology, third edition). Blood pressure is the measurement of the pressure difference of the blood level in a position, referenced to another position using a transducer. It is measured by both direct and indirect method. There are three ways in direct method using a transducer. Firstly, it involves the placing a catheter in the blood stream. In this way, the transducer is not in the body and the blood pressure is transmitted through a solution in the catheter to the transducer. Secondly, a needle or catheter is place in the vessel just under the skin. Thirdly, the transducer is placed permanently in the blood vessel or the heart (Biomedical instrumentation, Second edition).

(Picture taken from http://www.medical-scrubs.com)

Figure 3.2 Picture of sphygmomanometer

The indirect method is measured by placing a rubber cuff wrapped around a person's upper arm. The inflation of the rubber cuff will compresses the large artery in the arm, momentarily stopping the blood flow. When air in the cuff is released, the blood starts to pulse through the artery and makes a sound. Sounds continue to be heard using the stethoscope until the pressure in the artery exceeds the pressure in the cuff. When the sound stops, the measurement will be taken. Two measurements are recorded, Systolic pressure and Diastolic pressure. Systolic pressure is the pressure of the blood flow when the heart beats (the pressure when the first sound is heard). Diastolic pressure is the pressure between heartbeats (the pressure when the last sound is heard). Blood pressure is measured in millimetres of mercury, which is abbreviated mm Hg. The harder it is for blood to flow, the higher the number will be. A systolic pressure below 120 mm Hg or a diastolic pressure below 80 mm Hg is “Normal “condition of the body (Clinical Cardiology, sixth edition).

The process of measuring is classified manual, semi automated or the fully automated. The manual method uses a sphygmomanometer. The person taking the measurement will be required to inflate the cuff and listen to the sound and take reading from the scale on the sphygmomanometer. The process can be sped up by using the semi-automated blood pressure monitor (BPM) to sense the transmission of the sound as a pulse reference to a timer but the person is still required to inflate the cuff. The fully automated blood pressure monitor (BPM) inflates the cuff and listens to the sound. The person is only required to read the value of measurement (Biomedical instrumentation, Second edition).

The stroke volume is the measure of the volume of blood in each stroke (Exercise physiology, third edition). It determines the amount of blood that is passing through the position where the measurement is taken in each stroke. The blood volume is the quantity of blood in the blood vessels. The method of measuring the blood volume and stroke volume are similar to the method of measuring the blood pressure and it is measured using the direct method (Biomedical instrumentation, Second edition).

The pulse is the indirect measurement of the heart rate which reflects the heart beat via the blood arteries (Clinical Cardiology, sixth edition). It is measured using indirect method (Biomedical instrumentation, Second edition).

3.4.3 Measurement of the blood

The parameters for blood are blood viscosity and peripheral resistance (Exercise physiology, third edition). The blood viscosity measures the quality of the blood which is the quantity of the content of blood in each specified amount of blood. Blood is taken from the body to undergo laboratory tests. The peripheral resistance affects the efficiency of the blood flow. (Exercise physiology, third edition).

3.5 Instrument to measure the cardiovascular system

The different instruments are used to measure these parameters. These parameters involve the use of equipment or laboratory test to define the performance of the three components.

3.5.1 Equipment

The parameters of the cardiovascular system can be measured by two methods, direct and indirect. The direct method involves a cut in the body to place a transducer into the cardiovascular system to take measurement (Biomedical instrumentation, Second edition). This method will produce a more accurate measurement but it is not convenient and it has a certain risk of infection. This method is suitable only when the accuracy of the measurement is critical like a critical patient in the incentive care unit or the patient in the operation room.

The indirect method is also known as the physical examination (Clinical Cardiology, sixth edition). The measurement is taken physically on or near the skin which is more convenient. It is almost risk free.

Indirect method of measuring the parameters is preferred in this project. Indirect method of measuring has the following benefits:

- Convenient

  The measurement is taken on or near the skin which make measurement convenient. It also allows measurement to be taken repeatedly.

- Risk (Risk of infection)

  Indirect method involves only the contact with the skin or even non-contact, hence the risk involved is relatively small.

- Cost

  The manufacturing cost for the equipment is much lower than those equipments used for direct method.

The disadvantage of the indirect method includes:

- Accuracy

  When the sensor of the equipment is nearer to the heart, the accuracy of the measurement will be better. Hence, indirect method is less accurate compared to the direct method.

- Factors affecting the accuracy of readings

  The accuracy of the measurement will also be affected by other factors like the motion of the body.

- Insufficient measurements

Under critical circumstances, continuous monitoring of parameters of the cardiovascular system is required. Direct method can provide readings of the component of the cardiovascular system instantly.

(Clinical Cardiology, sixth edition)

3.5.2 Laboratory test

Most parameters of the cardiovascular system are measured using equipments. For example, the heart rate and blood pressure are measured using heart rate meter and blood pressure monitor respectively. Other parameters that measure the concentration of the blood or related factors required laboratory testing to determine its value. For example, the blood content and the resistance in the vessels required laboratory tests (Exercise physiology, third edition).

3.6 Selection of parameters and instrument

The selection of the parameters is determined by the importance of the parameter, the method and the equipment. Hence, table 3.1 summarized the method and its equipment according to the parameters.

	Parameters	**Method**	**Medium of measurement**
1	Pulses	Indirect	Pulses meter
2	Blood pressure	Indirect	1. Sphygmomanometer 2. Semi-automated BPM 3. Fully-automated BPM
		Direct	Transducer
3	Blood volume	Direct	Transducer
4	Stroke volume	Direct	Transducer

5	Blood viscosity	Direct	Laboratory test
6	Peripheral resistance	Direct	Indirect measurement via calculation
7	Heart rate	Indirect	Heart rate meter
		Direct	Transducer
8	Heart rhythm	Indirect	ECG machine
		Direct	Transducer

(Exercise physiology, third edition)

Table 3.1 The method and equipment used to mean the parameters

Of all the parameters mentioned above, the blood pressure and pulse is selected for the project.

The main reason is the importance of these two parameters. A stable rate of the heart beat reflects a stable operating condition of the heart. A change in the blood volume, stroke volume and peripheral resistance can be predicted by a change in the blood pressure. Both parameters can be measured indirectly

3.7 Conclusion

This chapter illustrated the selection of the equipment to measure the parameter of the cardiovascular system which concludes to use a blood pressure monitor to measure the blood pressure and pulse of the cardiovascular system. The next chapter will discuss about the characteristic of the equipment.

Chapter 4

Equipment

4.1 Introduction

Chapter three has illustrated the parameters of the blood pressure and pulse and this chapter will illustrate the equipment to measure both the blood pressure and the pulse. This measuring equipment is essential to the project. This equipment is the source of the information health data. It is a blood pressure monitor with capability to measure pulse. The selection of the equipment and some common equipment in the market will be discussed in this chapter. This chapter will also have a detail description of the function of the equipment, the interpretation of the information and the signal that is coming out from the equipment.

4.2 Selection of measuring equipment

This project focused on two parameters which is the blood pressure and pulse as the interpretation of health data. There is a variety of equipment to measure these two parameters. Usually, the blood pressure monitor is used to measure the blood pressure and the heart rate meter is used to measure the pulse. There is also equipment that can measure both parameters. Equipment is mostly similar in its function but additional features are added depending on the usage and the cost.

The usage of the equipment is grouped into three:

- extensive usage

  The person is required to wear the equipment for 24 hours. For this usage, the ambulatory blood pressure monitor is used to measure the blood pressure whereas a holter meter is used to measure the heart rate.

- periodic usage

  The person will take the measurement in an allocated time.

- occasional usage

  The person seldom measures.

In this project, the usage of the equipment is between extensive and periodic. The measurement is taken in periodic and transferred to the computer to analyses.

4.3 Current product on the market

Currently in the market, equipments are categorizes in three groups

- Automatic blood pressure monitor

  Automatic blood pressure monitor have the capability of inflating the cuff automatically.

(Picture taken from http://www.50plushealth.co.uk)

Figure 4.1 Picture of an automatic blood pressure monitor

- Manual blood pressure monitor

The manual blood pressure monitor will allow the user to inflate the cuff manually.

(Picture taken from http://www.epinions.com)

Figure 4.2 Picture of a manual blood pressure monitor

- Wrist blood pressure monitor

The wrist blood pressure monitor takes the measurement from the wrist of the arm.

(Picture taken from http://asseenontvpicks.com)

Figure 4.3 Picture of a wrist blood pressure monitor

Both manual and automatic blood pressure monitor takes measurement from the upper arms and the wrist blood pressure measures from the wrist. The market is currently moving toward providing more features and new blood pressure monitor usually come with automatic inflation function. For example, Omron have only a hand full of product that is manual inflated and most are currently automatic inflated. Table 4.1 shows a comparison chart with a list of blood pressure monitor with different features. Omron is not the only company providing blood pressure monitor equipment. Companies like Lifesource, J. Hewitt and SunTech also carries a series of blood pressure monitor but Omron is the leading band in Asia.

Additional features of the equipment include:

1 Memory capability

The memory capability refers to the number of readings that can be stored in the equipment.

2 Accuracy of reading

The accuracy of reading refers to the consistency of the reading. Different measurement taken within a small period of time should not have a big variation in the value.

3 Error detection of readings

The error detection of readings refers to the intelligence of the equipment to detect inaccurate readings. For instance, incorrect positioning or shaky while taking measurement.

4 Downloading capability

The downloading capability refers to the ability of the equipment to transfer the readings to a computer.

5 Pulse measuring capability

This refers to the ability to measure pulse.

The equipment for this project requires these all the features above.

The memory and downloading capability feature affects the price of the equipment. Equipment that has all the features other than the downloading capability is much lesser than the price of those without downloading capability. Equipments that have higher capacity of memory will usually cost slightly more. The comparison chart in table 4.1 also list different blood pressure monitor with their features.

Features	IA1	IA1B	IA2	IW1	IW2	R8IT	M5	MX-3	R-A1	M2	T9P	HEM-907
Intellisense technology	√	√	√	√	√	√					√	√
Automatic Inflation	√	√	√	√	√	√	√	√	√		√	√
Wrist				√	√	√			√			
Cuff	Fit Cuff	Fit Cuff	Fan-shaped cuff	Wrist Cuff	Wrist Cuff	Wrist Cuff	Fan-shaped cuff	Fan-shaped cuff	Wrist Cuff	Fan-shaped cuff	Fan-shaped cuff	Fan-shaped cuff
Standard cuff size provided	17 - 32 cm (S-M)	22 - 42 cm (M-L)	22 - 32 cm	13.5 - 21.5 cm	13.5 - 21.5 cm	13.5 - 21.5 cm	22 - 32 cm	22 - 32 cm	13.5 - 21.5 cm	22 - 32 cm	22 - 32 cm	22 - 32 cm
Fast measurement	√	√	√	√	√	√					√	√
Memory (sets of readings)	90	90	90	90	90	90	14		21	14	28	
Date & Time Display	√	√	√	√	√	√			√		√	
Average of last 3 readings	√	√	√	√	√							
Detects Irregular heartbeat	√	√	√	√	√							
Body movement indicator	√	√	√									
Advance Position Sensor						√	√					
AC jack (optional)	√	√	√	√	√	√	√	√	√	√	√	√

(Source: Omron Healthcare Singapore)

Table 4.1 Comparison chart of different blood pressure from Omron

4.4 Features of IA2

Figure 4.4 Picture of IA2

IA2 is the equipment chosen for this project due to three main reasons.

1. The size

The size of the equipment is not compact therefore it is easier to investigate the equipment.

2. The price

The cost of the equipment is relatively cheaper than others.

3. The features

The equipment have memory feature with date and time but it does not have the downloading capability.

This equipment has the following features:

1. Memory capability

IA2 can hold 90 sets of memory with date and time.

2. Accuracy of reading

IA2, like many of Omron product, has Intellisense technology. The Intellisense technology is an ability to take a few readings and provide the average of the readings as the final readings. It also removes ambiguous readings. This greatly improves the accuracy of the reading.

3. Error detection of readings

IA2 can also detect irregular heartbeat and body movement. By taking a set of readings, when these readings are mostly ambiguous readings and with the motion detection of on transducer, it indicates that the person is moving while taking the readings. These set of readings can also interpret irregular heartbeat when the changes of the sys pressure and dia pressure values is not in a regular pattern.

4. Pulse measuring capability

IA2 can measure both the pulse and the blood pressure.

The only disadvantage of IA2 is it does not have the downloading capability.

4.5 Components of the IA2

Investigation is carried out to understand the components of the IA2. IA2 consists of 5 main components:

- The cuff with transducer
- The Microcontroller
- The power supply
- The Pump
- The LCD

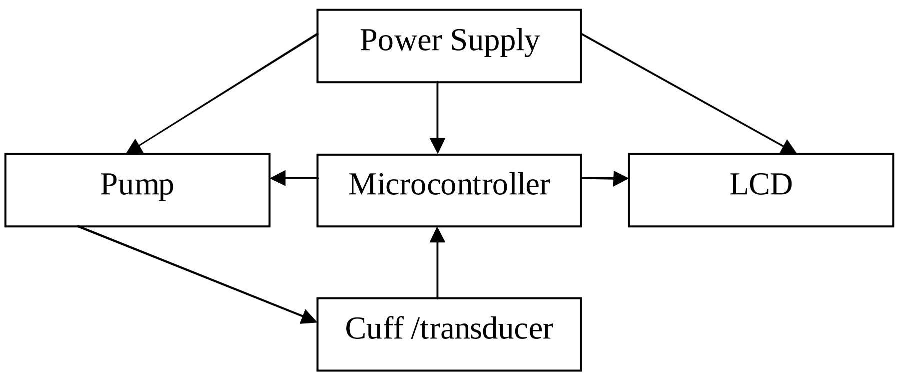


Figure 4.5 Relation between the five main components

These four components are linked to the microcontroller. This processor will activate the pump to ensure a sufficient amount of pressure is produced to inflate the cuff. During the inflation of the cuff, the transducer will take the pressure difference and transmit the information to the microcontroller. The microcontroller will interpret the information and process the calculation and display the relevant information on the LCD.

1. The cuff

The inflation of the cuff depends on the amount of pressure from the pump. This amount of pressure transmitted to the cuff will tighten the cuff. When the cuff is tightening, pressure acts on the blood vessel. Hence, when the blood vessel is been pressurized, it produce a sound wave. This sound wave is then picked up by the transducer.

2. The pump

The pump is responsible in producing certain amount of air pressure over a period of time. The increase of air pressure and the rate of increase of air pressure are controlled by the microcontroller.

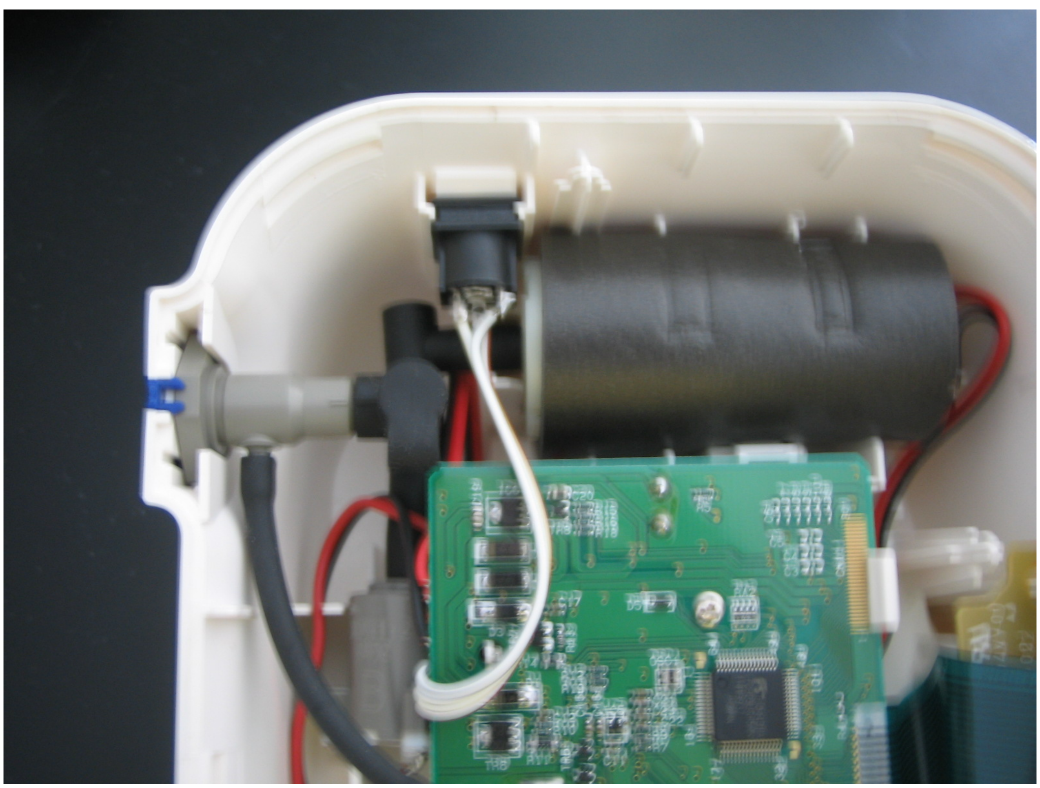


Figure 4.6 Picture of the pump of IA2

3. The LCD

LCD is a Liquid crystal display which displays the following information.

a. SYS (systolic pressure)

b. DIA (diastolic pressure)

c. PUL (the pulse)

d. Time and date

e. Memory (determine the information display is from the memory)

f. Error detection

g. Accuracy detection

h. Processing (a symbol to show that the equipment is taking measurement)

i. Heartbeat symbol (flash at each heartbeat)

j. Deflation symbol (flash while cuff deflating)

k. Battery low symbol (lighted when battery low is low)

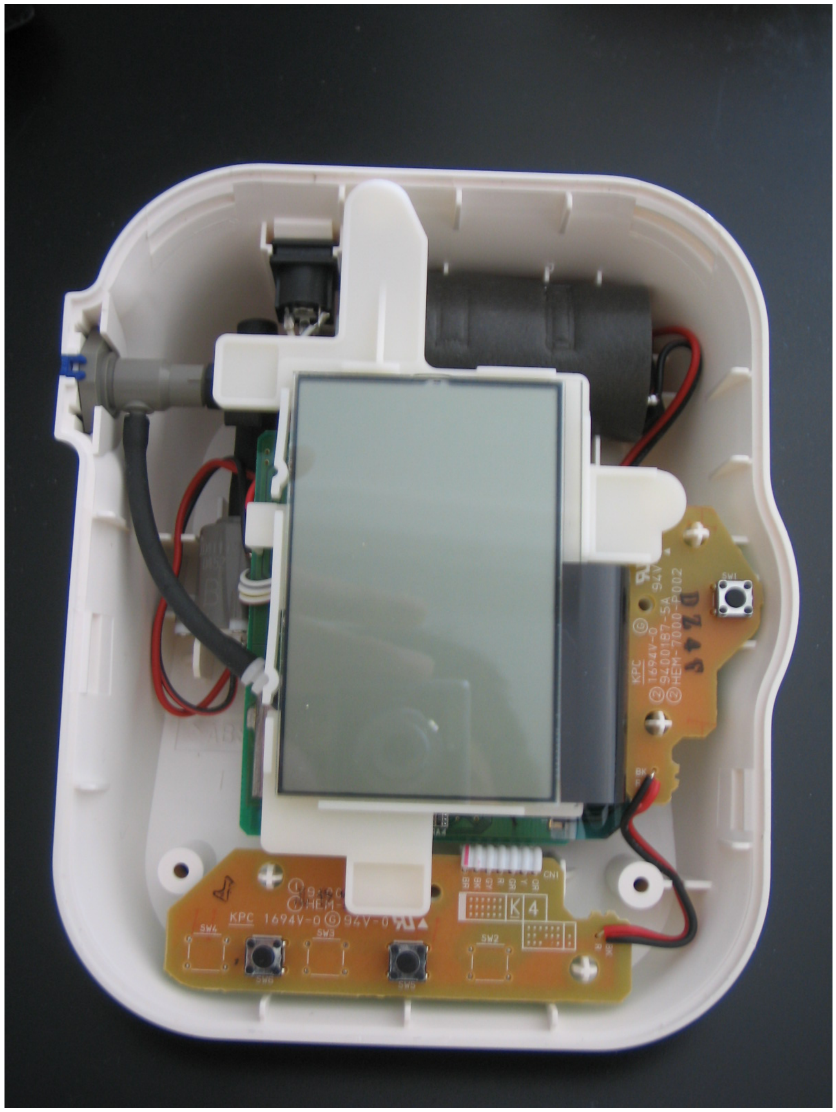


Figure 4.7 Picture of the LCD of IA2

4. The power supply

The power supply consists of four ‘AA’ batteries. Each ‘AA’ battery is 1.5V. This power supply is the source to all the components in the equipment except the cuff.

5. The microcontroller

The microcontroller plays the following roles in the equipment.

a. It controls the pressure and the rate of the increasing pressure which the pump is producing.
b. It transmits data to the LCD to light up the specify segment.
c. It receives information from the transducer
d. It processes the information from the transducer
e. It store information in its memory

The microcontroller used in this equipment is TMP86CP23. This chip is manufactured by Toshiba Company and has 48k x 8 bits of ROM and 2k x 8 bits of RAM.

The features of the microcontroller include:

- 8-bit single chip microcomputer
- Instruction execution time: 0.25µs - 122µs
- 731 basic instructions in 132 categories
- 20 interrupt sources (External 5, Internal 15)
- Input/ Output ports (48 pins) (program controlled)
- Output ports (3 pins)
- 18-bit timer counter: 1channel
- 8-bit counter: 4 channel
- Real Time counter
- Time Base Timer
- Divider output function
- Watchdog Timer
- Serial Interface
- 10-bit successive approximation type AD converter

- Multiply accumulate unit (MAC)
- Four key-on wake-up pins
- LCD driver/controller
- Dual clock operation
- Nine power saving mode
- Wide operating voltage

These features show that this chip's capability far exceeds the requirement of the equipment. Most of the features are not used.

4.6 Information Retrieval

There are two possible options to achieve this task.

a. Retrieve the information from the microcontroller

b. Retrieve the information from the LCD

1. Option 1

Retrieving the information from the microcontroller is the initial approach in this project. This approach has two possible ways.

a. Use the Serial Interface of the microcontroller

b. Use the information in the memory of the microcontroller

Both methods require an understanding of the instruction and decoding of the microcontroller.

Decoding the microcontroller is not an easy task as manufacturers usually enclose the microcontroller and reverse engineering of industrial or commercial product is violating the law. Hence, this approach is not selected.

2. Option 2

The objective is to understand the information from the microcontroller that transmits to the LCD to light up the segment. There are two possible areas to retrieve this information.

- The Output port of the microcontroller
- The Input pins to the LCD

The Output port of the microcontroller is not a preferred choice as the pins of the microcontroller is fairly small as each pin of the microcontroller is only 0.35 mm and by probing to these pins will damage these pins.

4.7 Characteristic of this LCD

This LCD has 34 pins and required a continuous supply of signal. Each segment of the LCD depends on a pattern of one or more segment output signal and a pattern of common output signal.

4.8 Output of the microcontroller

Before investigating the input signals of the LCD, there is a need to carry out some study on the microcontroller. This will highlight what the expected signal in the input of the LCD’s.

4.8.1 LCD driving methods

The microcontroller can provide 5 types of driving method

1. 1/4 duty (1/3 bias)
2. 1/3 duty (1/3 bias)
3. 1/3 duty (1/2 bias)
4. 1/2 duty (1/2 bias)
5. Static

The driving method of the driver will affect the frequency and the drive voltage for the LCD.

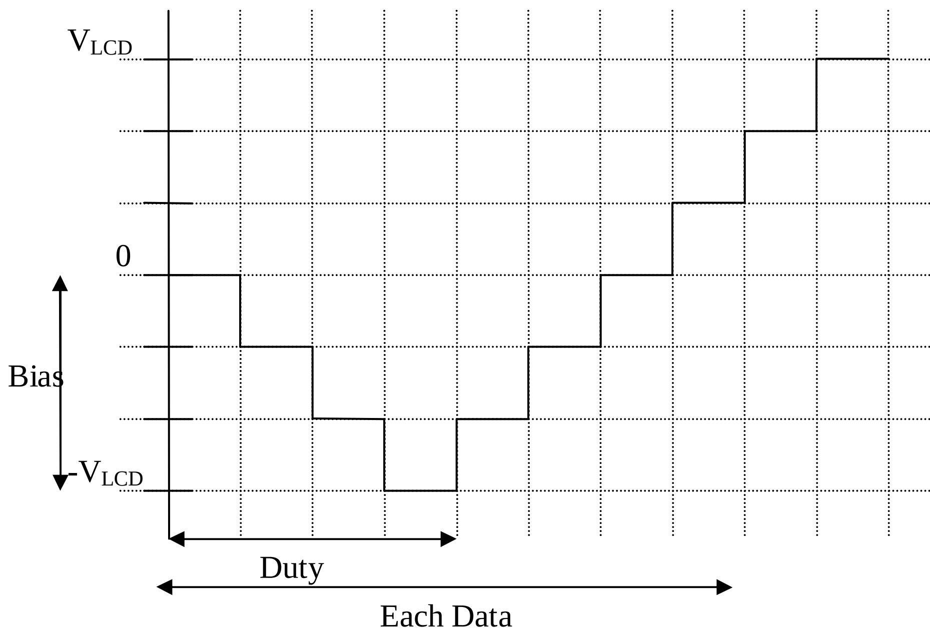


Figure 4.8 The waveform of 1/4 duty (1/3 bias)

For instance, figure 4.2 shows a 1/4 duty (1/3 bias) waveform.

The Duty refers to the frequency of the waveform.1/4 indicates that the value 4 is the frame frequency of the signal. This waveform will require two set of 4 bit to form a data.

The bias refers to the changes of the voltage. 1/3 indicates that there can be 3 level of voltage. The waveform will be fall under six different section of voltage.

The microcontroller can operate under 5 different High-frequency clocks which are 16MHz, 8MHz, 4MHz, 2MHz and 1MHz and 1 Low-frequency clock which is 32.768kHz.

The voltage level of the LCD depends on the application of the driving method. The V_{LCD} must work within the range of V_{DD} and V_{SS} which is between 0V to 5V. V_{LCD} is the working voltage of the signal to the LCD, V_{DD} is the operating voltage of the LCD and V_{SS} is the ground.

Common outputs are consistent signal used for the LCD as a referencing signal. Hence, the status of the Segment is directly dependant on the waveform of the Segment outputs.

4.8.2 Operation of the LCD

The microcontroller is able to provide up to 32 different segments output (SEG) and the 4 different common output port (COM). The amount of common needed for the operation will depends on the frame frequency. Table 4.2 shows the relation between the frame frequency and the common output port (COM).

Frequency	COM3	COM2	COM1	COM0
1/4 Duty	Used	Used	Used	Used
1/3 Duty	Not Used	Used	Used	Used
1/2 Duty	Not Used	Not Used	Used	Used
Static	Not Used	Not Used	Not Used	Used

Table 4.2 Relation of frame frequency and Common output port

4.9 Waveform from the input of the LCD

Waveform from the input of the LCD can be achieved by using an oscilloscope. One end of the oscilloscope is connected to the pin of the LCD and the other is connected to the ground of the equipment. This process is repeated four times on all the 34 pins and the reading are recorded in a table in appendix B. The table contains the voltage level in each two duty cycle with columns as the two duty cycle and rows as the number of the pin. In each reading, the display on the LCD is also recorded.

4.9.1 Characteristic of the waveform

The waveform repeated after 2 duty cycle which mean that each data is 2 duty cycle. This shows that the microcontroller is using 1/4 duty for the frame frequency.

The waveform has 3 voltage levels which shows that the microcontroller is using 1/3 bias.

Using the two points above that concludes that the driving method of the microcontroller is 1/4 duty (1/3 bias) Drive.

4.10 1/4 duty (1/3 bias) driving method

After the driving method of the microcontroller has been identified, a step is taken farther to derive the segments that are required to produce a numerical figure and the Segment output that produce these numerical figure and study the waveform characteristic of 1/4 duty (1/3 bias) driving method.

4.10.1 The segments required to produce a numerical figure

1/4 duty (1/3 bias) drive uses 2 segment outputs and 4 common outputs to control the display of a figure. Each segment output control four segments and each common output controls two segments. This combination of control will produce eight combination of relation between a segment output and a common output. The relation between each segment output with a common output will control the status of each segment. In each numerical figure there are seven segments and a dot. The dot display is not used in this equipment.

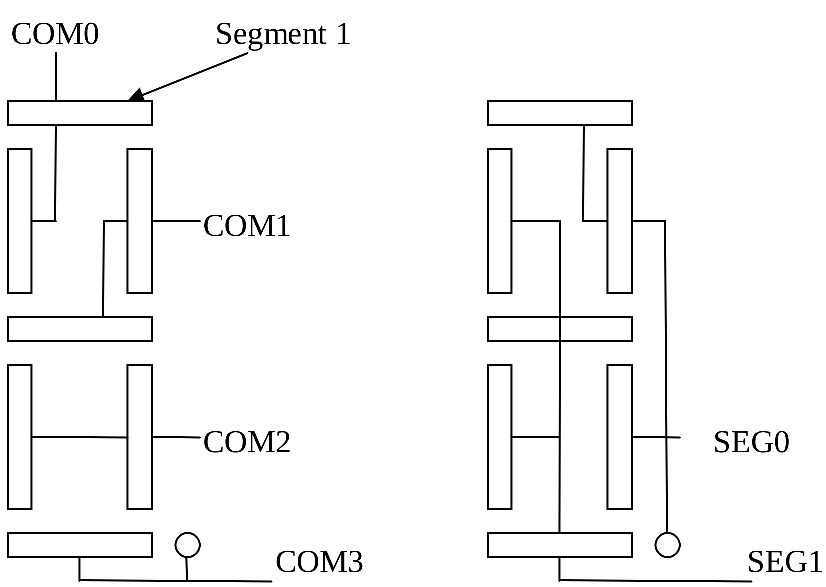


Figure 4.9 Relationship between common outputs with segments and segment output with segments

Figure 4.3 shows the relationship between common output with segments and segment output with segments. For instance, segment 1 is controlled by common put 0 (COM0) and segment output 0 (SEG0).

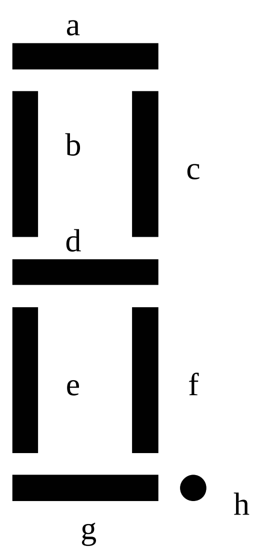


Figure 4.10 Labelling of the segment of the display figure

Segments	Segment outputs	Common outputs
a	SEG0	COM0
b	SEG1	COM0
c	SEG0	COM1
d	SEG1	COM1
e	SEG1	COM2
f	SEG0	COM2
g	SEG1	COM3
h	SEG0	COM3

Table 4.3 The relationship between the segment outputs, common outputs and the segment

Figure 4.4 shows the segment of the display figure and table 4.4 summaries the relationship between the common output with the segments and segment output with the segments.

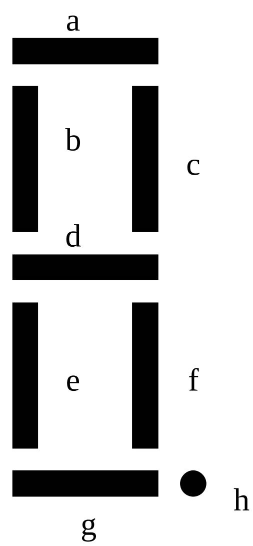


Figure 4.11Labeling of the segment of the display figure

Numerical figures	Segment							
	a	b	c	d	e	f	g	h
0	1	1	1	0	1	1	1	0
1	0	0	1	0	0	1	0	0
2	1	0	1	1	1	0	1	0
3	1	0	1	1	0	1	1	0
4	0	1	1	1	0	1	0	0
5	1	1	0	1	0	1	1	0
6	1	1	0	1	1	1	1	0
7	1	0	1	0	0	1	0	0
8	1	1	1	1	1	1	1	0
9	1	1	1	1	0	1	0	0
.	0	0	0	0	0	0	0	1

0 = Not Used, 1 = Used

Table 4.4 Relation of the segment to the numerical figures

Table 4.4 shows the required segments to display a numerical figure. For instance, to display a ‘1’ in the LCD, segment c and segment f will have to light up.

4.10.2 Waveform from the Segment Output

There are two focuses in the waveform from the Segment Output.

1. The frequency of the waveform
2. The different level of voltage of the waveform

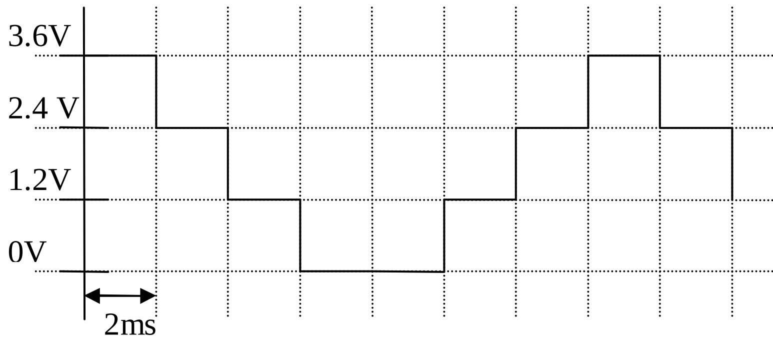
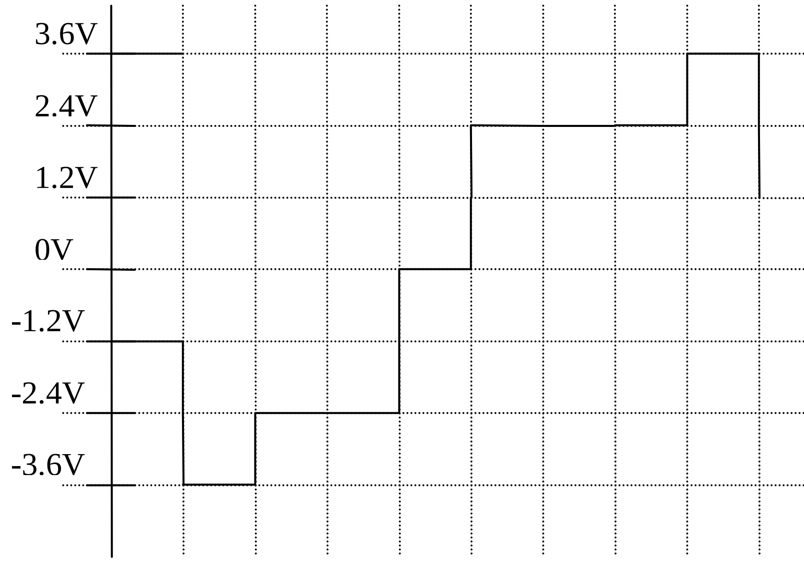


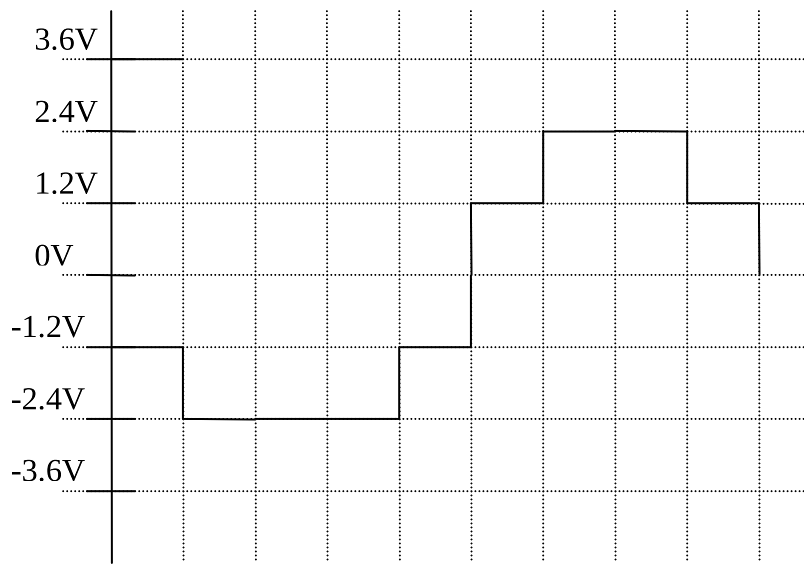
Figure 4.12 The period and voltage level of the waveform of a 1/4 duty (1/3 bias)

4.10.2.1 The combination of the waveform

Status of each Segment of the display figure will depends on the combination of the segment output and the common output. This can be derived be taking common output minus segment output. When the common output minus segment output, the voltage that achieve V_{LCD} or $-V_{LCD}$ indicates that segment is lighted up.



Common output - Segment output
(Selected)



Common output - Segment output
(Non-Selected)

Figure 4.13 Waveform of common output minus segment output (selected and non-selected)

When the common output minus segment output, voltage levels cancel each other and produce another waveform. It also changes the range of voltage level from a 0V to V_{LCD} to range of voltage level from V_{LCD} to $-V_{LCD}$. For instance, in 1/4 of a duty cycle the voltage level of common output is 3.6V and the voltage level of segment output is 0V, the waveform will be at voltage level 3.6V. Taking another example, in 1/4 of a duty cycle the voltage level of common output is 0V and the voltage level of segment output is 3.6V, the waveform will be at voltage level -3.6V. Both the instances above are able to achieve V_{LCD} or $-V_{LCD}$. When V_{LCD} or $-V_{LCD}$ is achieved, the output will produce logic '1'. Whereas when V_{LCD} or $-V_{LCD}$ is not achieved, the output will produce logic '0'. A pulse is generated with a change in the logic level and a continuous pulse will light the segment. On the other hand, a pulse is not generated when the output remains at logic '0'. This is because when the common output minus segment output, it is not able to achieve V_{LCD} or $-V_{LCD}$.

4.11 Conclusion

The selection of the equipment involves several steps which includes the usage analysis, market equipment research, the equipment feature analysis and the model of blood pressure from Omron. This chapter includes the investigation of the equipment which involves in the function of the main component of the equipment, the characteristic of the microcontroller, the LCD driver of the microcontroller and the signal characteristic of the signal from the input of the LCD. The next chapter will focus on the interface circuit required for the communication between the equipment and computer.

Chapter 5

Interface Circuit

5.1 Introduction

After understanding the signal from the input of the LCD, this chapter will illustrate the circuitry required to transmit the information to the computer. Two important factors will be discussed throughout the chapter that is the frequency and the voltage level. The objective of the circuitry is to convert the parallel signal of the LCD to a series signal transmit to the computer at same frequency.

5.2 Expectation of the circuitry

The interface circuit is required to convert LCD signal to the computer's receiving level. It required the signal from many output to be converted to one series signal. To achieve this, there are two important factors to consider:

1. Matching the voltage level of both LCD signal and the computer
2. Matching the frequency of both LCD signal and computer

In this project, there are four steps taken for the development of these circuits.

1. Select the peripheral to communicate with the computer
2. Convert different voltage level to uniform voltage level
3. Convert the parallel signal to a single serial signal
4. Adjust the frequency to suit the frequency of the computer

5.3 Selection of the communication with the computer

Firstly, selection of peripheral to communicate with the computer is essential.

The types of techniques of communicating with the computer are:

1. RS-232
2. Parallel port
3. USB port
4. Infrared red
5. Wireless communication
6. Modem
7. LAN communication

5.3.1 RS-232

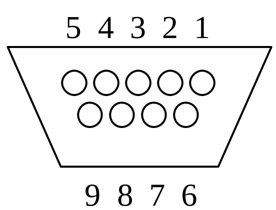
RS-232 is a widely used technique to interface external equipment with computer. It uses serial communications where one bit is sent along a line, at a time. The main advantage of serial communications is it required less hardware compare with other form of communications. It uses a single wire to transmit and another to receive.

The electrical characteristics of RS-232 define the minimum and maximum voltages of logic ‘1’ and ‘0’. Logic ‘1’ is about -12V and logic ‘0’ is about +12 V. Any voltage between is considered an indeterminate logical state. If there is no pulse present on the line then the voltage level is equivalent to a high level which is -12V.

There are 2 types of connectors for RS-232

1. DB9S (9 pins)
2. DB25S (25 pins)

DB25S is the actual standard for RS-232 but nowadays most computers are using the DB9S connector as DB9S is sufficient for serial data transfer. In most computer there is at least a serial communication which usually known as COM1. Figure 5.1 show the relation of the pins and the signals.



Pins	Signals
1	Not in use
2	Rx
3	Tx
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	Not in use

Figure 5.1 RS-232 DB9S interface

In this project, ‘no handshake communication’ technique is used. This technique requires less hardware. In ‘no handshake communication’ technique, there are two assumptions, no lost of data during communication and all data is successfully transferred during the transmission. The no handshake technique required only 3 pins for the transfer of data, the Rx, Tx and GND. Rx is the receiving pin, Tx is the transmitting pin and GND is the ground. Figure 5.2 shows the connection between the computer and the interface hardware.

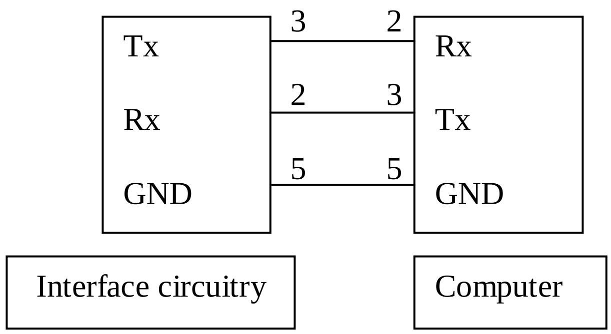


Figure 5.2 The connection between the computer and the interface hardware (no-handshake technique)

5.3.2 Hardware interfacing required by serial port

Due to the different in the working voltage level, the RS-232 required a voltage levelling build up between the interface circuit and the computer.

There are three possible methods of levelling the voltage:

1. Use a single chip Transmitters/Receivers
2. Use a Transmitters chip and a Receivers chip
3. Use Transistor and operational-amplifier

In this project, a single chip Transmitters/Receivers is a better option. The cost between the three methods is minor.

This single chip is usually known as the RS-232 Transmitters/Receivers IC. This IC role is to amplifier the voltage level from 0-5V to -12V - +12V and during the process the signal is inverted. Figure 5.3 shows a typical connection of a RS-232 Transmitter/Receivers IC which will be used in this project.

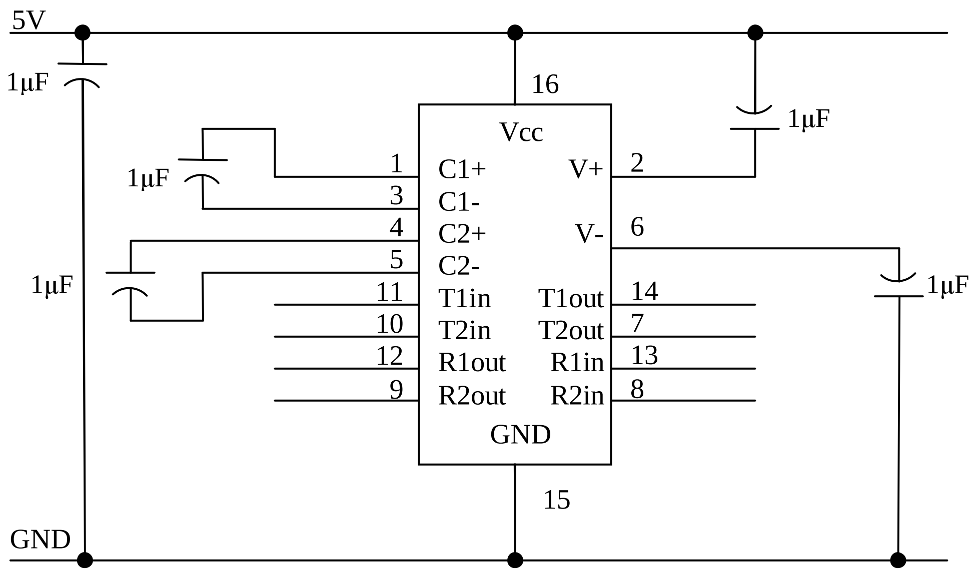


Figure 5.3 A typical connection of a RS-232 Transmitter/Receivers IC

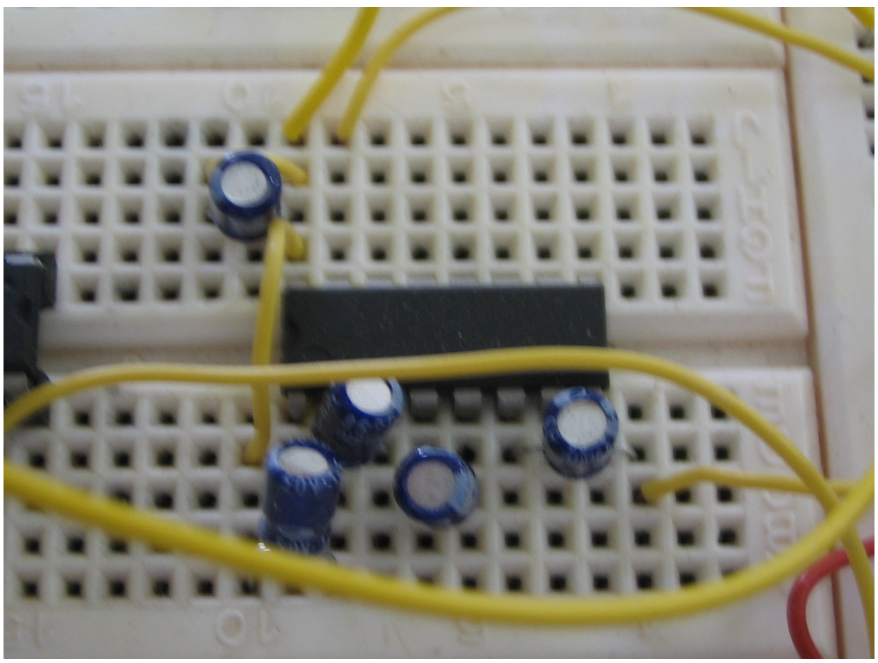


Figure 5.4 A picture of the RS-232 Transmitter/Receivers IC

5.4 Convert different voltage level to uniform working voltage

The signal from the input of the LCD has four different levels of voltage, 0V, 1.2V, 2.4V and 3.6V which are shown in figure 5.4. These four levels of voltages are required to be converted to component working voltage which is 0V and 5V.

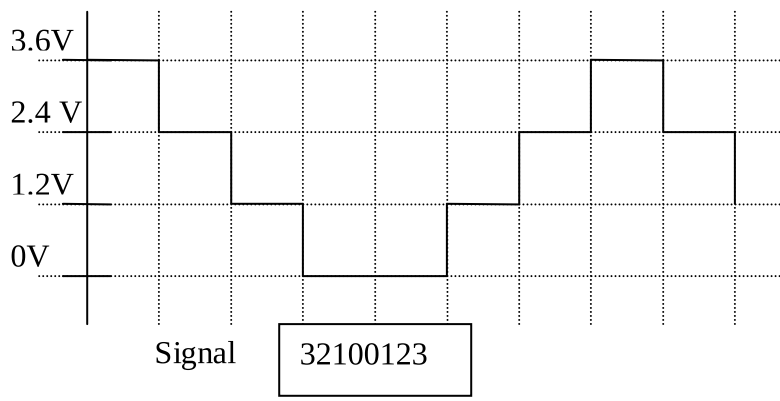


Figure 5.5 A possible signal from the input of the LCD

To convert the signal above, the signal will be spilt into three signals.

A reference voltage will chop between the differences in the voltage level. Voltage level that is above the reference voltage level will produce Logic ‘0’.Whereas the voltage level that is below the reference voltage level will produce Logic ‘1’.

Voltage reference	Signal Voltage	Output Voltage	Logic
Between 0V to 1.2V	0V	5V	‘1’
	1.2V	0V	‘0’
	2.4V	0V	‘0’
	3.6V	0V	‘0’
Between 1.2V to 2.4V	0V	5V	‘1’
	1.2V	5V	‘1’

	2.4V	0V	‘0’
	3.6V	0V	‘0’
Between 2.4V to 3.6V	0V	5V	‘1’
	1.2V	5V	‘1’
	2.4V	5V	‘1’
	3.6V	0V	‘0’

When the signal voltage is below the voltage reference, the output voltage will be 5V.

When the signal voltage is above the voltage reference, the output voltage will be 0V.

Table 5.1 Relation between signal voltage, output voltage and logic with voltage reference

To accomplish voltage levelling, two small circuit need to be developed.

1. Power supply with four different voltage levels
2. Voltage comparator

5.4.1 Power supply

The power supply required to produce three different level of voltage. The first voltage level is 5V which is the working voltage level for all components. The other three voltage levels act as a voltage reference for the voltage comparator. The mean of the different between the voltage levels of the signal will be the voltage reference which is 0.6V, 1.8V and 3V. The connection is shown in figure 5.5.

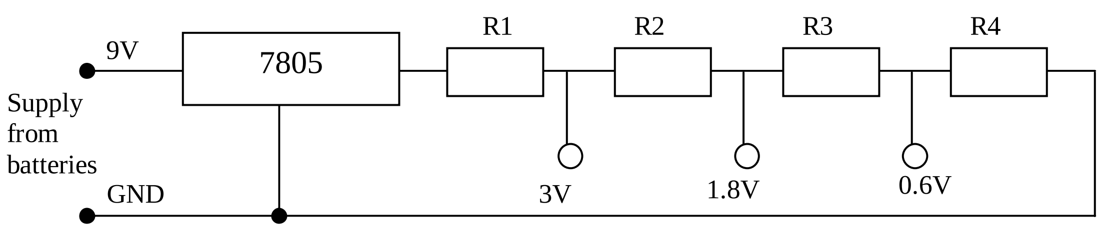


Figure 5.6 Circuitry of power supply

The R1, R2, R3 and R4 are resistors value to achieve the voltage level. Figure 5.6 shows the circuitry of the resistors.

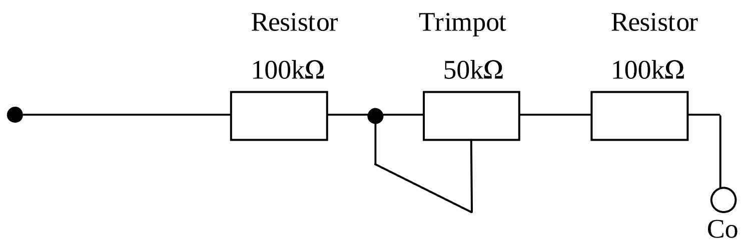


Figure 5.7 Circuitry of R1, R2, R3 and R4

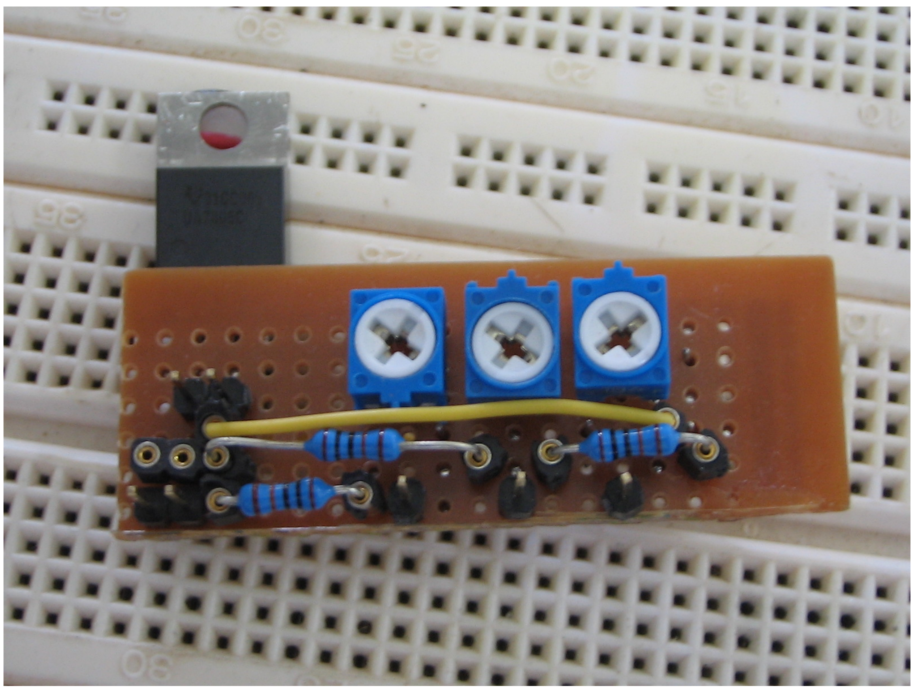


Figure 5.8 A picture of power supply circuit

The power source of the interface circuit is 6 ‘AA’ batteries. These 6 batteries will produce 9V which the 7805 chip requires (at least 7V).

5.4.2 Voltage comparator

Voltage comparator uses a voltage reference to determine the status output voltage. There are 2 types of component can be used as voltage comparator:

1. Operational amplifier
2. Comparator

Table 5.2 shows the voltage comparator with the IC code and description.

Components	IC Code	IC description
Operational amplifier	LM741	General purpose op-amp
	LM747	Dual op-amp
	LM1458	Dual op-amp
	LM748	Op-amp
	LM3900	Quad op-amp
	NE5534N	Low- noise op-amp
	NE5534AN	Ultra low-noise op-amp
	LM4136	Quad High performance op-amp
	LM4558	Dual High performance op-amp
Comparator	LM393	Low power dual comparator
	LM311	Voltage comparator
	LM339	Quad low- power comparator
	LM393	Dual low- power comparator

Table 5.2 List of IC for operational amplifier and comparator

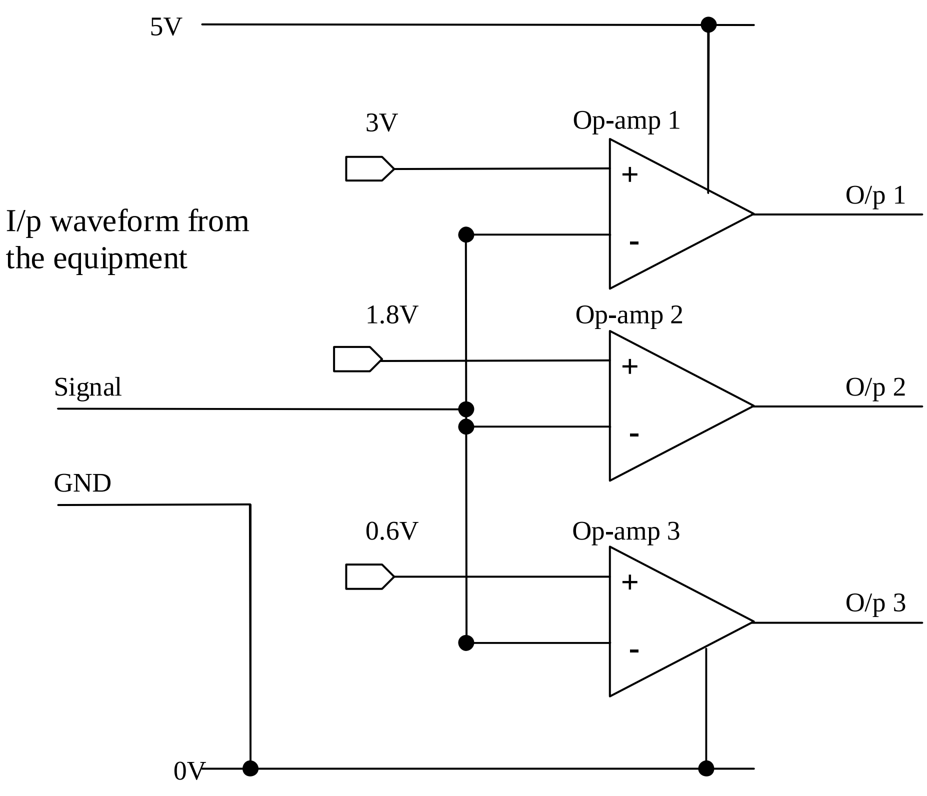


Figure 5.9 Circuitry of voltage comparators using operational amplifier

The connection of the op-amp is shown in figure 5.7 but both operational amplifier and comparator have similar problems. They are not able to work with voltage level below 1V which mean it is difficult to detect differences in the voltage level between 1.2V and 0V. 1.2V might be higher than 1V but the difference between 1V and 1.2V is small. Practically, due to input offset voltage, current leaking and response time of the component, the voltage comparing will fail. Input offset voltage can be compromise by using operational amplifier. Modification to the voltage comparator circuit is required to countermeasure for current leaking and response time. One possible solution is to deal with the difference in voltage level individually. The threshold voltage reference of the 1.8V and 3V will remains but the threshold voltage of 0.6V will required additional circuitry. The input signal from the LCD will have to push the voltage level to 1.5V.To achieve this, there are 2 possible methods:

- Use a transistor
- Use an amplifier IC

Transistor will be preferred as it is much cheaper than the amplifier IC. Figure 5.8 shows the connection of the transistor which will be used in this project.

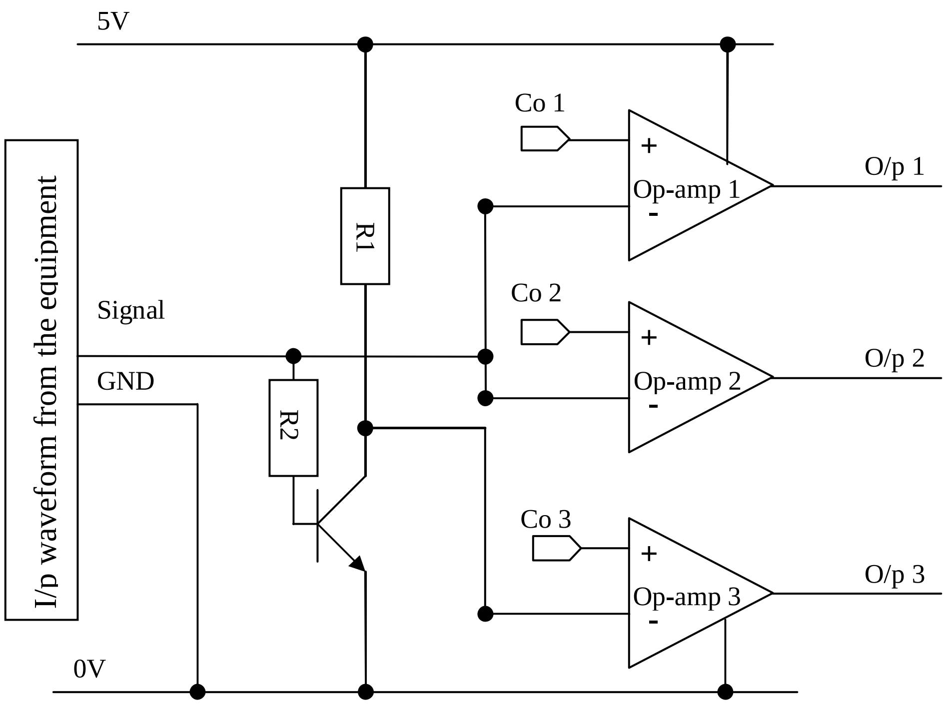


Figure 5.10 Circuitry of voltage comparators using operational amplifier with transistor

R1 and R2 are pull-up resistors. Both resistors are about 330ohms.

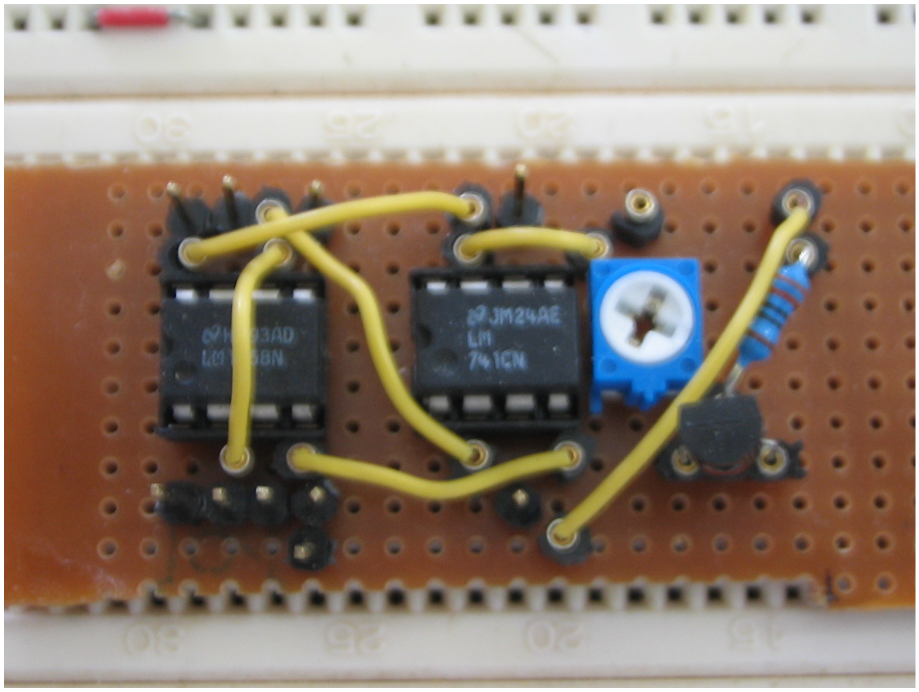


Figure 5.11 A picture of voltage comparators using operational amplifier with transistor

5.5 Convert the parallel signal to a single serial signal

There are 33 signals from the LCD and after the processing by the voltage comparators the number of signals increased to 99. This amount of signal is required to convert from parallel to series. There are three methods of converting parallel to series:

1. Use a parallel to series IC
2. Use a microcontroller with at least 99 inputs
3. Use flip flop

But none of the methods above can achieve the conversion. The combination of two or more of the methods is required to achieve the task. Method 1 and 2 is the best combination for this project.

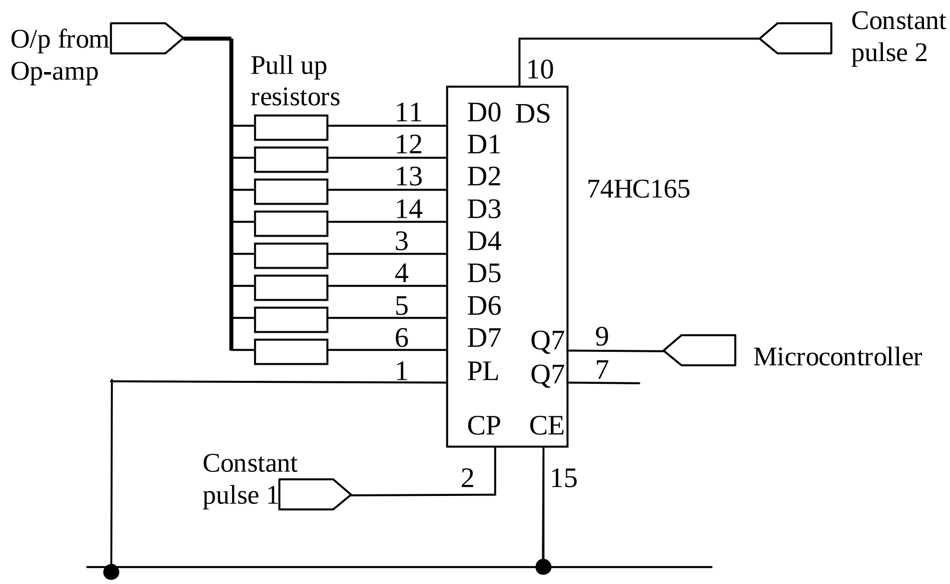


Figure 5.12 Circuitry of the parallel to series IC 74HC165

A parallel to series IC will help reduce the number of inputs to the microcontroller. 74HC165 is a parallel to series converting IC. This IC required a constant period of pulse (Constant pulse 1) and another pulse that is three times faster than the constant pulse (Constant pulse 2). Constant pulse 1 will be connected to CP which will be used to clock the transmission of the output. Constant pulse 2 will be connected to Ds which will be used to select the receiving of the bit. The circuitry of 74HC165 is shown in figure 5.9.

Microcontroller is another component that can be used to convert parallel signal to serial signal. The signal will be connected to the ports of the microcontroller and transmitted using a program. Details will be discussed in section 5.7.

5.6 Adjust the frequency to suit the frequency of the computer

Frequency is in fact the most important aspect of the signal processing. There are three important factors to be considered:

1. Frame format of transmission
2. The frequency of the signal from the input of the LCD
3. The frequency of the computer is receiving data

The frequency of the signal from the input of the LCD is different from the rate computer is receiving data. The frequency of the input of the LCD must be close to the frequency of the computer receiving rate to reduce the error generated during transmission.

5.6.1 Frame format of transmission

All transfer of data of a circuit with external source will required a standard of confirmation. RS-232 with no handshake uses three bit as confirmation. These three bits are start bit, stop bit and parity bit shown in figure 5.9. These three bit will enclosure a set of data to be transmitted.

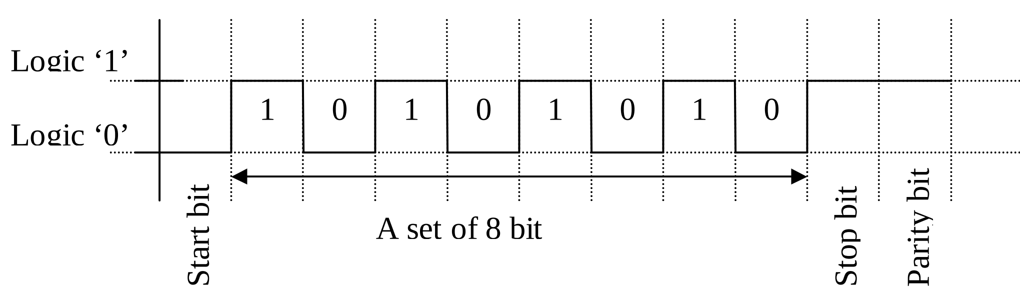


Figure 5.13 RS-232 frame format

5.6.2 The frequency of the signal from the input of the LCD

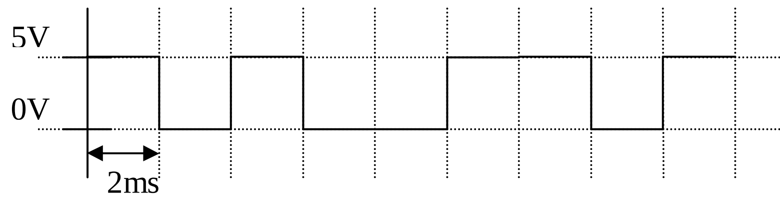


Figure 5.14 The period of the waveform of a 1/4 duty

The time interval between each triggering point of the input signal is 2ms which mean the rate of transmission of the signal is 2ms per bit. In each data, there is 8 bit. Then the total period is 16ms.

5.6.3 The frequency of the computer is receiving data

The baud rate of the computer receiving data can be selected using the 300, 1200, 2400, 9600, or 19200. The microcontroller required a baud rate of 1500 to transmit 11 bit of per data. This baud rate is not a standard baud rate of the computer receiving data. A higher baud rate is required. 2400 baud rate is the next better choice but the difference between 1500 and 2400 baud rate is not much. Hence, 9600 is a preferred baud rate for the transmission.

Microcontroller is usually a suitable way of changing the frequency of the signal. This is because microcontroller can accommodate different frequency of input and transmit in another frequency. The receiving and transmitting of the signal using a microcontroller can be controlled using the program. The only disadvantage is the cost.

5.7 Microcontroller

Due to time constraint, the development of the microcontroller is incomplete. The development of the microcontroller is connected between the RS-232 circuit and the signal processing circuit. The microcontroller is used to receive the signal from the signal processing circuit at 16ms per duty cycle and transmit to the computer at 9600 baud rate. The development of the microcontroller involves the following steps:

1. The selection of the microcontroller
2. The connection of the microcontroller
3. The programming of the microcontroller
4. The testing of the microcontroller

5.7.1 Selection of microcontroller

There are three features require of the microcontroller:

1. With a serial interface to the computer
2. With at least 3 input port
3. With internal timer

The 16PIC628 microcontroller has the above features and in addition, this microcontroller also have internal clock generator. This means it does not required a crystal to generate a pulse as the clock of the microcontroller.

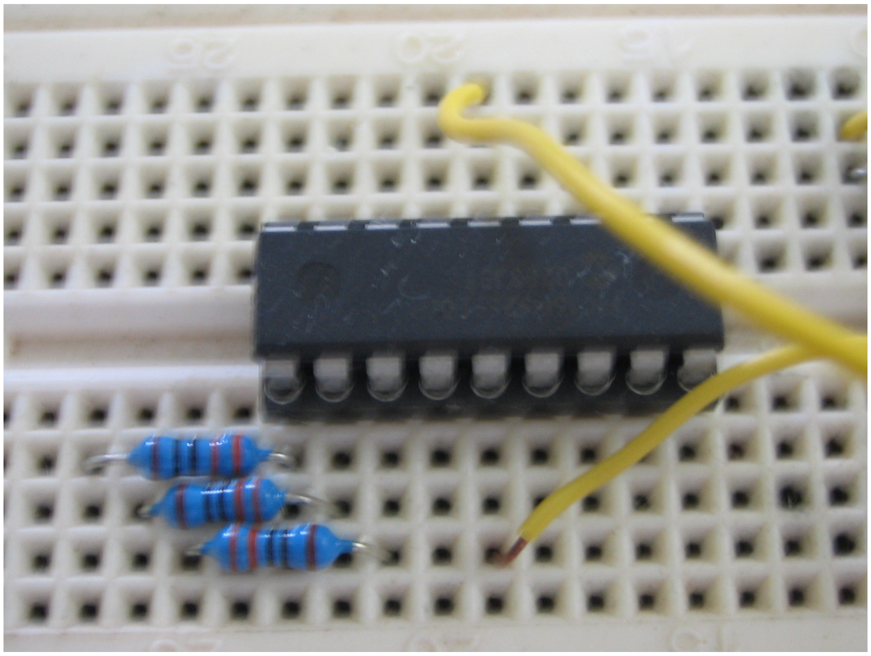


Figure 5.15 A picture of the microcontroller 16PIC628A

5.7.2 The connection of the microcontroller

The connection of the microcontroller involves only three steps:

1. The 3 op-amp output is connected to the port B of the microcontroller from PB4 to PB6
2. The Rx, Tx and the Gnd from the serial cable from the computer are connected to the Tx, Rx and Gnd of the microcontroller.
3. The V_{SS} and V_{DD} is connection to the power supply circuit

Figure 5.12 shows the connection of the microcontroller.

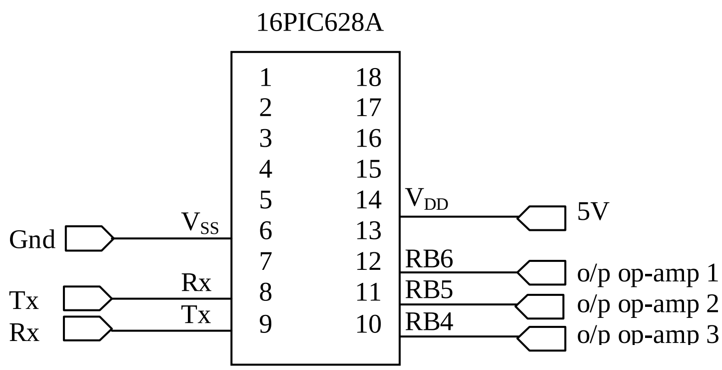


Figure 5.16 Circuitry of the microcontroller 16PIC628A

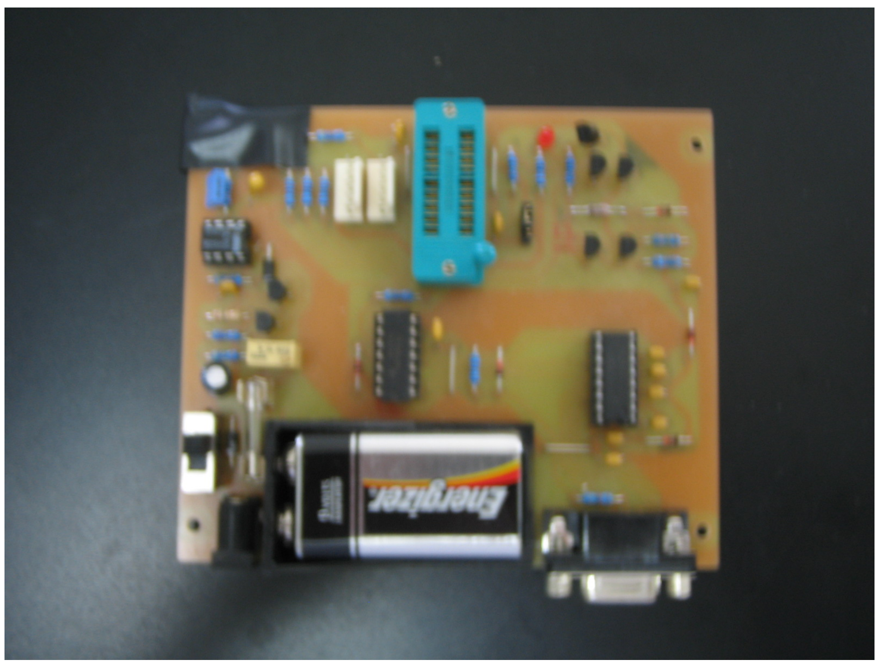


Figure 5.17 A picture of the microcontroller 16PIC628A programmer circuit

5.7.3 The programming of the microcontroller

The programming of the microcontroller required much time due to the limitation of the programming instruction type and the program instruction. Hence, the development of the microcontroller halts at this point but the flow of the program is developed.

Initialization of the program includes the following steps:

1. Clear the ports (A and B)
2. Turn off the comparator
3. Enable the pin
4. Configure port B as output
5. Turn on the interrupt of port B (RBIF interrupt)
6. Turn on the USART (Tx)
7. Set the baud rate of transmission
8. Turn on the USART (Rx)

The main program includes two routines:

1. The routine to receive the signal
2. The routine to transmit the signal

The frequency involves in the signal receiving and the frequency to transmit is different. This requires a timer (Timer 0) and the RBIF interrupt. The interrupt is activated when there is a change of status in the signal received from the input of the op-amp. The timer is used when there is no change of state from the input of the op-amp.

5.8 Problem encountered and Recommendations

There are three problems encountered in the development of the interface circuit that contribute to the incompletion of the project.

Problem 1

The development of the signal processing circuit for the interface circuit required a huge amount of components. The input of the LCD has 33 pins which required a 99 op-amp to achieve the full interface circuit. These have not included the parallel to serial IC that is required to convert parallel to serial which is then connect to the limited amount of microcontroller.

Solution

The development of the signal processing circuit is reduced to using only 3 op-amps which is connected to a pin. This reduced circuit serves as a prototype for the actual circuit.

Problem 2

The time required to develop the microcontroller is longer then expected. This is due to:

1. The microcontroller used for the project required a different set of program instruction.
2. The program instruction of the microcontroller is limited. It increases the difficulty of writing the program. For instance, the program instruction does not have a compare instruction that the comparison of a byte with another byte. Instead, the program uses a bit detection instruction that check for only a bit in a byte. The program instruction also does not have a condition branch. Instead, it has a definite branch.

Solution

Testing is included in the circuit to simulate the expected result. The program also includes a simulation of the possible data received from the interface circuit.

Problem 3

The development of the circuit between the microcontroller and RS-232 IC has not completed. The RS-233 is used to connect between the microcontroller and the computer.

Solution

The RS-232 circuit is developed using the MAX-RS-232 with 5 1μF capacitors. A simulation of the RS-232 circuit is made using a pulse generator to transmit a signal from the input of the RS-232 and this signal is acknowledged by a test program of the RS-232 in the computer.

5.9 Testing of the circuitry

Many parts of the system are affected by the incompletion of the interface circuit. Testing is developed in each individual area to test the functionality of each area. The testing includes:

1. The testing of the power supply

   Testing is carried out using a voltage meter and measure the voltages of the output of the power supply created using 7805 and resistors.

2. The testing of the signal processing

   Testing is carried out in the output of the op-amp and observed the waveform using an oscilloscope.

3. The testing of the RS-232 circuit

   The signal is tested in two steps. Firstly, a pulse is applied to the input of the Rx using a pulse generator and observed the output of the Rx using an oscilloscope. The same process is repeated to the other Rx and two Tx. Secondly, the circuit is connected to the computer via a serial cable and test the acknowledge signal using a RS-232 test program.

5.10 Conclusion

The development of the interface circuit involves the design of the circuits, the selection of the type of components, the selection of the chip and the connections of the circuits. Due to the problem encountered to develop the microcontroller circuit, the workability of each circuit is tested. The next chapter will illustrate the development of the program used to interpret the signal into useful health information.

Chapter 6

Program

6.1 Introduction

The last task of the project is to establish a program to interpret the data received from the equipment through the interface circuit. The program aims to interpret the data into useful information that can help doctor or user to understand the health condition and identify critical health condition.

6.2 Programming tool

To develop the program, the programming language is important. There are numerous programming languages that can be used for the project. This includes:

1. C++ programming
2. Visual basic programming
3. Web page programming
4. Java programming

The Visual Basic is selected for the program development tool for this project because:

1. Visual basic provides computer generated code for Graphical User Interface.

   This feature reduce the need for the programmer to write code for the design of the layout and components of the Graphical User Interface

2. Visual basic allows import of system file for application program

   This feature allows programmer to link system source file with the program.

6.3 Program development

There are two approaches in developing the program:

1. Providing Graphical User Interface

   Graphical User Interface of the program includes providing interactive to the user.

2. Program for application

   The program is required to establish the communication between the external source and the computer.

Primary task of the program includes

1. User particulars
2. Data receiving
3. Data processing
4. Data presentation

6.3.1 Layout of program

The layout of the program is the initial setting of Graphical User Interface. The option for the layout of the program depends on the application and the programmer:

This includes:

1. Creating a main form and having the minor pages created within the main form
2. Creating a Tab control with tabs as the number of pages
3. Creating a Tree View that display the structure of the program
4. Creating a main menu that select individual page

The program for this project uses a Tab control layout. This tab control allows user to select the tab and change from one page to another. Tab control is useful for a program that has a small amount of pages and each page has a distinct purpose. Tab control is also suitable for progressive application.

6.3.2 User particulars

The first task is to create Graphical User Interface for user particulars. The setting of the Graphical User Interface for user particular will depend on the marketing direction of the product of the project. There are two directions:

1. The product is for single user

   If the product is for one person then the user particular will be entered once only. This mean the next start up of the program will advance to the downloading tab of the information display tab.

2. The product is for multi-user

If the product is for more than one person then the program will have to include user select feature. Security will have to be included for more than one user as health information is private.

The marketing of the product targets to reduce the cost of the product, in order to encourage more people to purchase the product. When more people purchased the product implies that more people will be practicing self- measuring of the health. Therefore, the program of the project customizes to be suitable for single user.

The first and second tab of the program contains the user particular. The first tab is to allow the user to enter user's particulars.

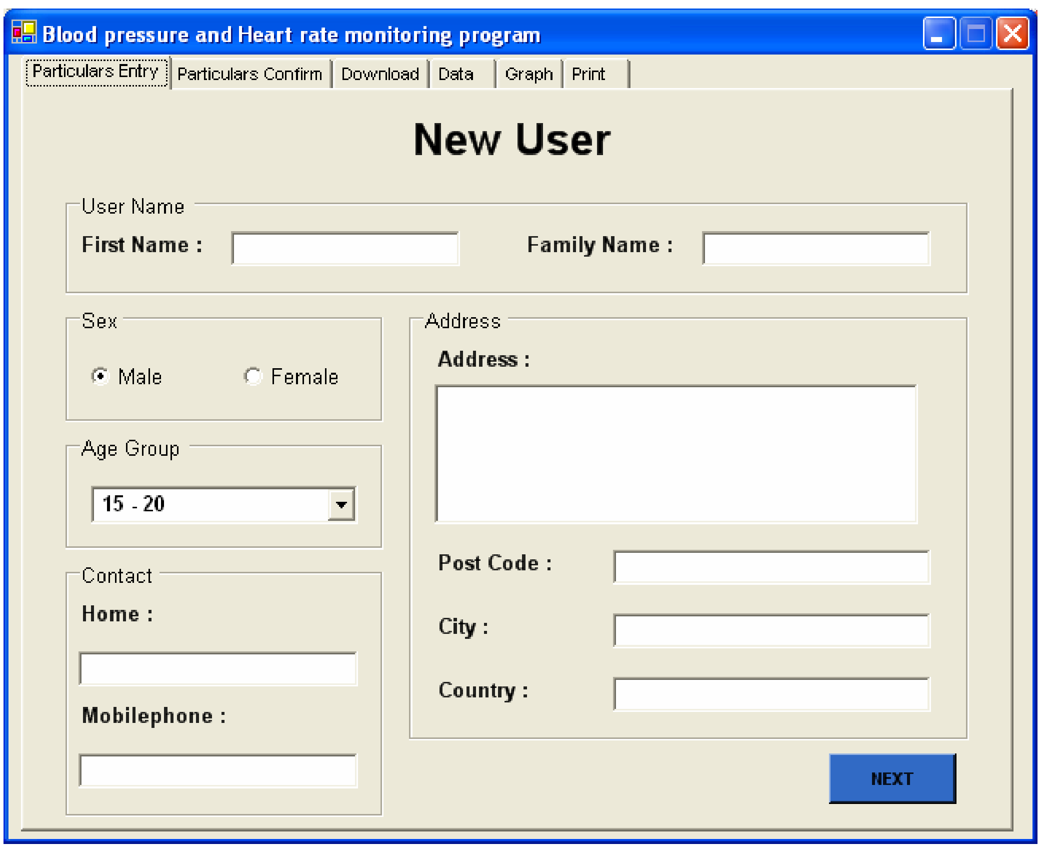


Figure 6.1 Tab 1 of the program

The second tab is a confirmation tab that contains all the information that is being entered in the first tab.

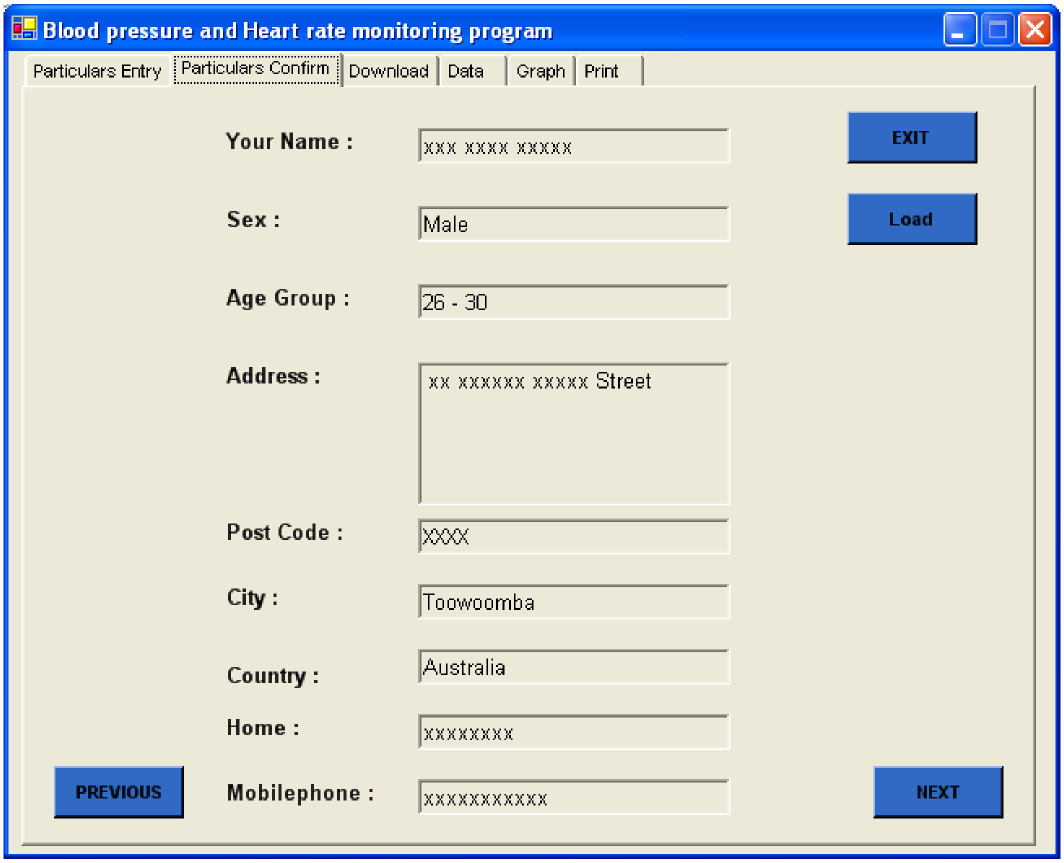


Figure 6.2 Tab 2 of the program

When the next button is hit, the user particular will be stored into a file format. In every start up of the program, the program will load the user particular and skip the first and second tab and advance to the third tab.

6.3.3 Data receiving and Data processing

Tab 3 is the 'Download' tab which is responsible for data receiving and data processing. Due to the time limitation and design restriction (More detail will be provided in chapter

5), the actual communication between the interface circuit and the program is not established. Instead, a simulation of the possible data is presented.

6.3.3.1 Data receiving

The program includes a feature to check for the communication port.

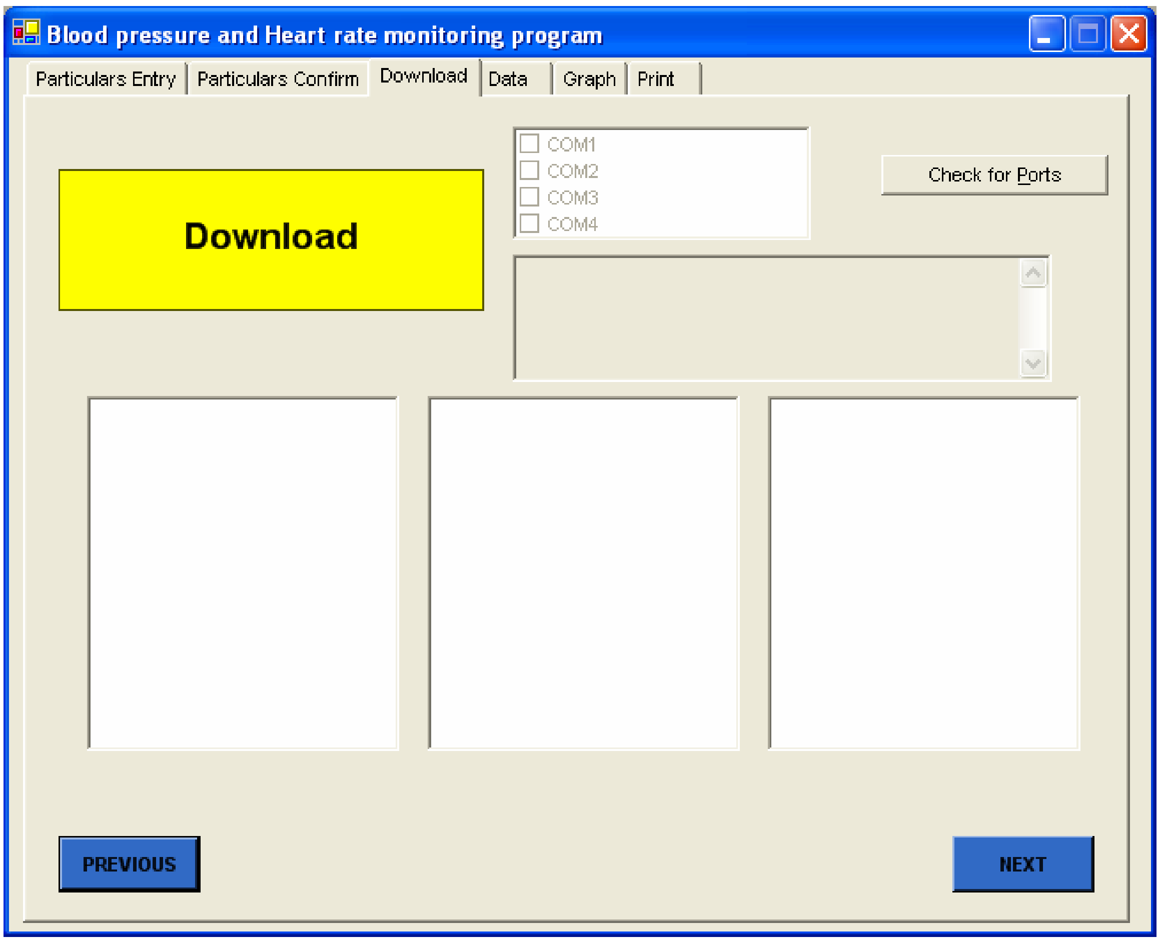


Figure 6.3 Tab 3 of the program

When the button ‘Check for Ports’ is pressed, the program scans the communication port of the computer and displays the ports that are available for communication. The communication port that is available for communication will be checked in checklist box beside the button.

6.3.3.2 Data processing

Assume all the data are received and all received data from the interface circuit is logic'1' and logic'0'; there should be 99 set of data and each set of data contains 8 bits. After signal processing of the interface circuit, the signal from the 33 inputs of the LCD will be converted into 3 set of signal from each input. Taking 33 multiple by 3, it will form the 99 set of data that will be transmitted to the computer. The 99 set of data will form an array of 3 x 33(i x j). The (j) represents the pin that produces that data whereas the (i) represents the data that is be converted by the interface circuit.

As all the signals are taken from the input of the LCD,

1. Each first set of data of i (if i = 0) represent the signal from the op-amp 3

   Logic'1' in the data represents GND in the signal from the inputs of the LCD
2. Each second set of data of i (if i = 1) represent the signal from the op-amp 2
3. Each third set of data of i (if i = 2) represent the signal from the op-amp 1

   Logic'1' in the data represents V_{LCD} in the signal from the inputs of the LCD

These sets of data are from the segment outputs which have not been processed with the common output. The first task of the program is to simulate COM – SEG. When COM – SEG, there is a co-relation between the common output signals, the bit and voltage level of the segment signal. Only the first four bit from the first set of data and the last four bit of the third set of data are related to the common output signal. Hence, only these bits are required to be processed by the program.

Common outputs	First set of data	Third set of data
COM0	Bit 7	Bit 3
COM1	Bit 6	Bit 2
COM2	Bit 5	Bit 1
COM3	Bit 4	Bit 0

Table 6.1 The relation between the bit and the common outputs

When common output – segment output, only segment outputs with voltage level of 0V, -V_{LCD} and V_{LCD} are of concern to the LCD. Voltages between these three levels will create a ‘Don’t Care’ situation for the LCD. Taking the relationship of the common output, bit and voltage of the signal from the input of the LCD into account, the program is required to detect logic ‘1’ of the first four bit of first set of data and the last four bit of the third set of data.

Through chapter four, it illustrates that the LCD require two segment to control each segment display (7 segments and a dot). Hence, the program is required to take into account the pins that are used to display the segment.

Parameter	Pins	i	Display
sys pressure	32	3	3rd numerical figure
	31	4	
	30	5	2nd numerical figure
	29	6	
	28	7	1st numerical figure
dia pressure	27	8	2nd numerical figure
	26	9	
	25	10	1st numerical figure
	24	11	
Pulse	23	12	3rd numerical figure
	22	13	
	21	14	2nd numerical figure
	20	15	
	19	16	1st numerical figure

Table 6.2 The function table of the parameters, display, pins and the array (i)

The program will have two tasks in data processing.

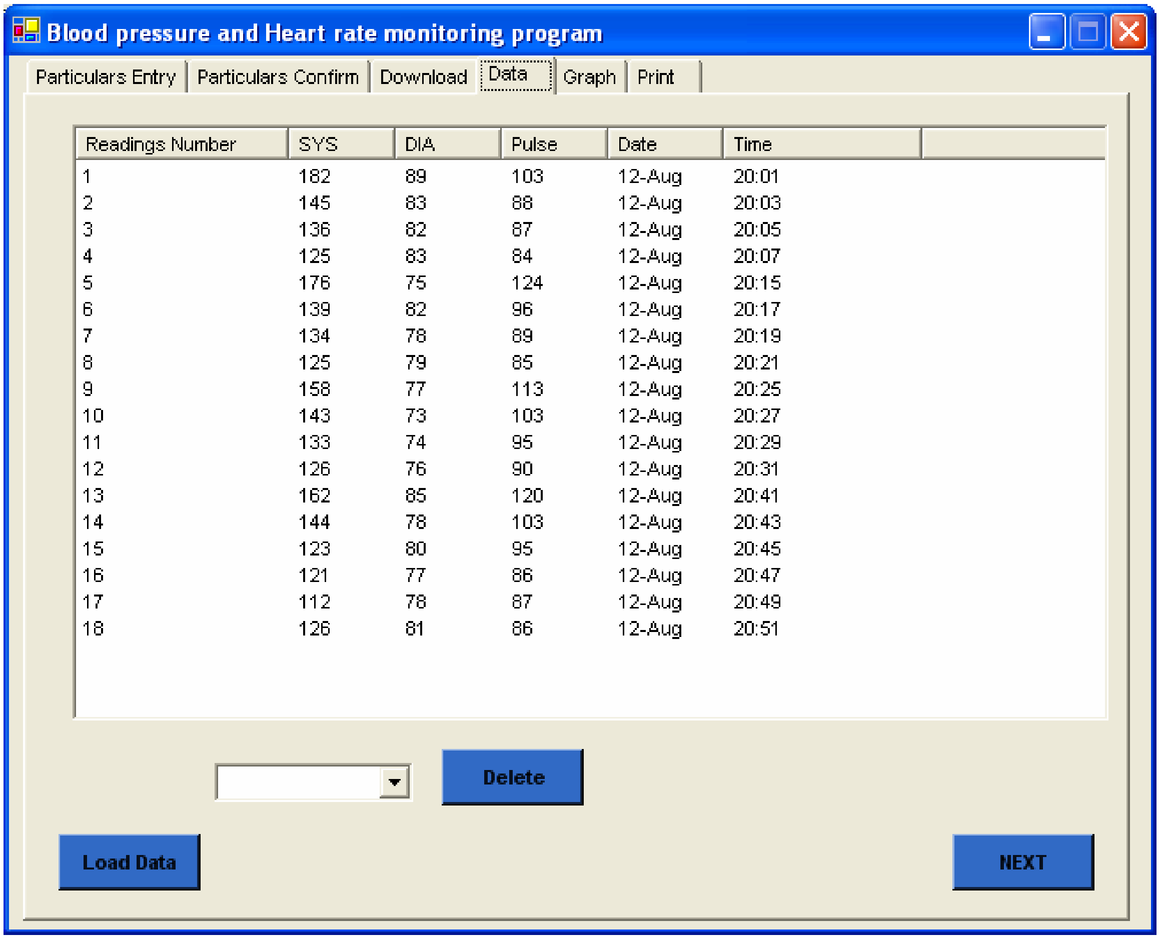
1. Identify the bit that presents the segment on the display
2. Identify the number of segment that presents the figure that is on the display.

6.3.4 Data presentation

Two tabs are associated with data presentation, Tab 4 and 5. Tab 4 is used to display a list of the health information. This includes:

1. Sys pressure
2. Dia pressure
3. Pulse
4. Date
5. Time

This information is sorted by the reading number. The ‘Load Data’ button will re-load the information.



Readings Number	SYS	DIA	Pulse	Date	Time
1	182	89	103	12-Aug	20:01
2	145	83	88	12-Aug	20:03
3	136	82	87	12-Aug	20:05
4	125	83	84	12-Aug	20:07
5	176	75	124	12-Aug	20:15
6	139	82	96	12-Aug	20:17
7	134	78	89	12-Aug	20:19
8	125	79	85	12-Aug	20:21
9	158	77	113	12-Aug	20:25
10	143	73	103	12-Aug	20:27
11	133	74	95	12-Aug	20:29
12	126	76	90	12-Aug	20:31
13	162	85	120	12-Aug	20:41
14	144	78	103	12-Aug	20:43
15	123	80	95	12-Aug	20:45
16	121	77	86	12-Aug	20:47
17	112	78	87	12-Aug	20:49
18	126	81	86	12-Aug	20:51

Figure 6.4 Tab 4 of the program

Tab 5 is a graphical display of the health information in Tab 4. Initial loading of the graph will display the sys pressure, dia pressure, and the pulse in the same graph. The x-axis of the graph will be the reading number and the y-axis will be the value of the parameter. The left y-axis will read the sys pressure and dia pressure value whereas the right y-axis will read the pulse value.

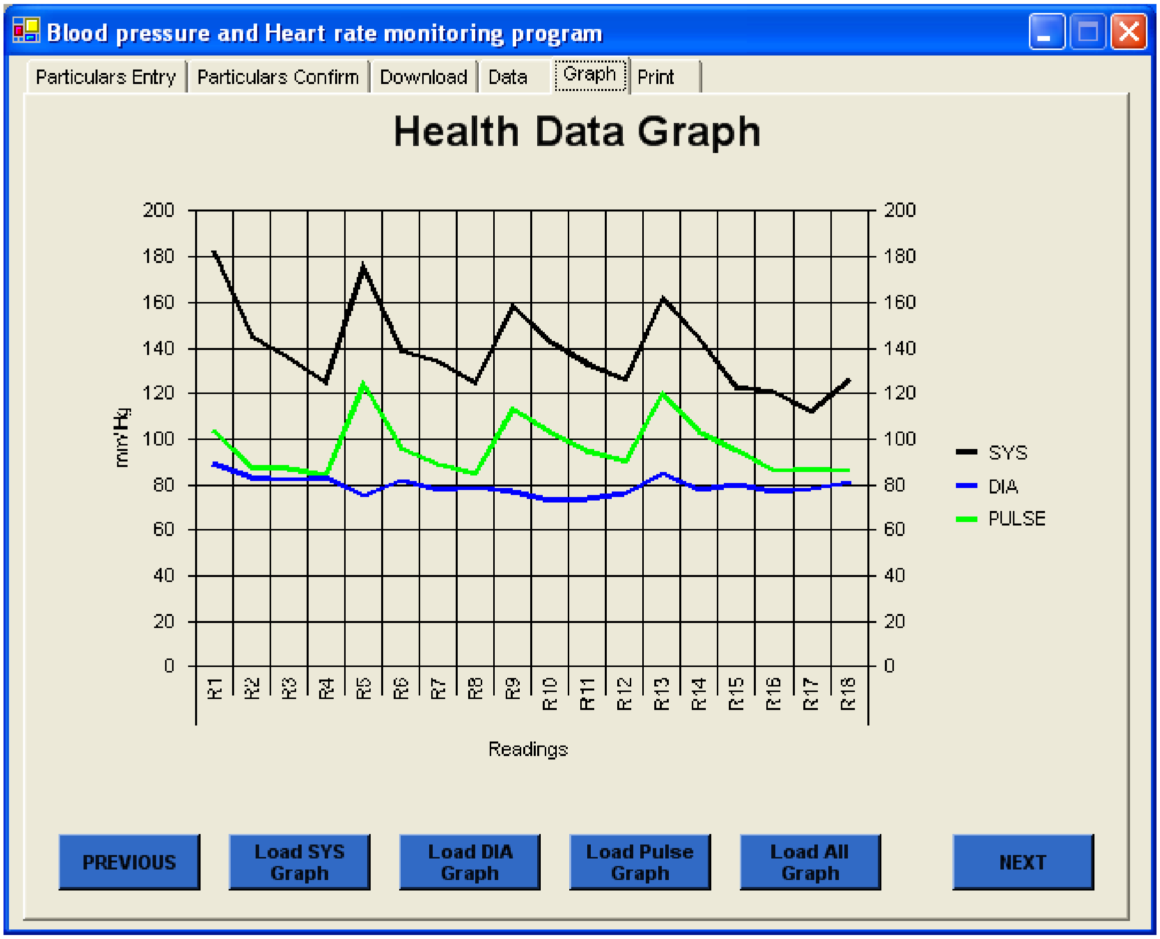


Figure 6.5 Tab 5 of the program

6.4 Additional feature of the program

The additional feature of the program is aim to improve the user friendliness of the program.

6.4.1 Start-up page

In every start up of the program, a start up page will present the title of the program with the creator's name. After two seconds, the start up page will close and start the main program.

6.4.2 Tab 1 User particular

In this tab, all the particulars are entered through text box except twp particulars, ‘Sex’ and ‘Age Group’. The ‘Sex’ uses a radio button function as there are usually only two possible option, ‘Male’ or ‘Female’. The ‘Age Group’ uses combo box function. This provides a list of preset category for the user to select.

6.4.3 Tab 2 User particular

All the particulars in this tab are marked. User cannot edit the user particular from this tab. User will have to hit the ‘Back’ button or use the tab function to get to tab 1 and do the editing.

6.4.4 Tab 4 Data

This tab includes a feature that allows user to delete the data in listed data. The user is required to select the particular readings to delete and hit the ‘Delete’ button. The program will delete the reading from the list, reduce the reading number by 1 and re-arrange the list. The program will also delete that reading from the file that stored the health information.

6.4.5 Tab 5 Graph

There are four buttons in the tab that is used to change the graph presentation, ‘Load SYS Graph’, ‘Load DIA Graph’, ‘Load PULSE Graph’ and ‘Load All Graph’.

1. ‘Load SYS Graph’ will display the graph using only the sys pressure value.
2. ‘Load DIA Graph’ will display the graph using only the dia pressure value.

3. ‘Load SYS Graph’ will display the graph using only the pulse value.
4. ‘Load SYS Graph’ will display the graph using sys pressure, dia pressure and pulse value.

6.4.6 Tab 6 Print

There are four option is Print tab, ‘Print Health Information’, ‘Print Health Information with Particulars’, ‘Printer Setup’ and ‘Print Preview’. ‘Print Health Information’ allows user to print the health information. ‘Print Health Information with Particulars’ allows user to print health information and user particular. The ‘Printer Setup’ allows user to setup the printer for printing and ‘Print Preview’ allows preview of the items to print.

6.5 Problem encountered and Recommendations

Due to the incomplete development of the interface circuit, the program development is also affected. The objective of receiving the signal from the equipment through the interface circuit could not be achieved. A simulation of the possible data received through an input file.

6.6 Testing of the program

The testing of the program includes:

1. The communication port testing

   The Tab 3 of the program also includes a button to test the availability of the port which can be used for communication between the interface circuit and computer.

2. The interpretation of the input data from an input file

The Tab 3 of the program is used to present a simulation of the program interpretation. In the Tab 3, it includes 3 list boxes. The first and the third list box from the left will display the data from the input file. The list box in the middle will display the number of segment that is lighted and follow by the actual value of the combination of the segment.

3. Testing of the user particular

The program includes GUI that allow user to enter the particular into the program. Ambiguous information is used to test the saving and the transfer from tab 1 to tab 2.

6.7 Graph Presentation

The graph in Tab is required to present useful information for the doctor and user. The presentation of the graph provides:

1. Alert about the control limit of the blood pressure and pulse
2. The trend on the rate of change of the blood pressure and pulse
3. The trend on the rate of the rate of change of the blood pressure and pulse

This information presented in the graph allows doctor or the user to have a clear picture of his/her health.

6.8 Limitation of the product

The product of the project targets for home user. The program is also customized for single user. This allows the user to have privacy on his/her health information. This limits the blood pressure monitor for individual. It is not suitable for use in incentive situation where there is need to critical need on the accuracy of the value of the parameter.

6.9 Conclusion

The program is responsible for the interpretation of the information from the equipment through the interface circuit. This chapter illustrated the programming tool, the layout of the program, the function of each Tab in the program and the simulation of the information using an input file. Graph presentation and limitation of the product are also included in this chapter. The next chapter concludes the project.

Chapter 7

Conclusion

7.1 Introduction

The project aims to develop a system to Monitor, Analyse and Report health data captured during exercise. The project is not able to achieve all the objectives due to the limitation of time and the complication of developing the system. This chapter will discuss the objectives achievement and further work.

7.2 Objectives and achievement

The objectives are achieved through the research of the topic and development of the system.

7.2.1 The research of the topic

The research of the project includes two parts:

1. The background research of the topic

Background research is the initial step for all projects. It is a process to gather information regarding or related to the topic of the project. A research is conducted before the development of the project and the following items are gathered:

a. The health of Australians in terms of economy and population
b. The cardiovascular disease
c. The function and structure of cardiovascular system and its components which are the heart, blood vessels and blood
d. The equipments used to measure parameters of the components of the cardiovascular system
e. The current blood pressure monitor on the market

2. The research on the technical information
    a. The technique and information of signal processing
    b. The components of developing circuitry
        i. Power supply circuit
        ii. Signal processing circuit
        iii. Parallel to series circuit
        iv. RS-232 circuit
        v. Microcontroller circuit
    c. The programming tools
    d. The programming code and programming technique

7.2.2 The development of the system

The developments of the system involve:

1. Purchasing of the select blood pressure monitor

   It involves the selection of the parameter of health information, the equipment to measure the parameter, the market product of the equipment and the different model of blood pressure monitor from Omron.

2. Investigation of the blood pressure monitor

   The investigation includes the components of the equipment, the function of the components, the characteristic of the microcontroller and the signal from the input of the LCD.

3. The selection of the components required for the interface circuit

   The selection of the components includes the type of component, the chip for those components and the design of the circuit.

4. The development of the interface circuit

   The development includes the connection of the chips a testing of the connection.

5. The selection of the programming tool for the program

   The visual basic is a better programming tool for this project due to the QUI and the application programming feature.

6. The programming of the program for the system

   The design of the program involves the design of the structure, the design of the layout, the style of programming and the selection of the code required.

7.2.3 The problem encountered

The unresolved issue of the project includes:

1. The developing of the microcontroller

The microcontroller is a critical component between the signal processing and RS-232 circuits. The detail of the microcontroller is discussed in chapter 5.7. The incomplete of the development of the microcontroller affected the development of the interface circuit and the program. Countermeasures of the program include creating simulation of the possible outcome and testing to output of all the circuit.

7.3 Further Work

The project leaves many rooms for improvement. The further work includes:

1. Complete the development of the signal processing circuit and the interface circuit

This involves the mass production of the signal processing circuit and the development of the microcontroller. The signal processing circuit developed in this project is only a prototype of the 33 circuitry.

2. Integrating the system with other equipment

This project selected the blood pressure and the pulse as the parameter. The project can develop to include more measuring equipment like blood content measuring equipment and heart rate meter.

3. Improve the user friendliness of the program

The presentation of the program still has rooms to improve. The font for example is too small for visual. There are also too many information listed in a single Tab. The program can be improved by changing the layout or the characteristic of the program parameters. The program can also introduce other interpretation of the information and present it differently.

4. Develop a blood pressure monitor with another microcontroller that has more LCD segment outputs and UART feature

The microcontroller in IA2 does not have sufficient output port for the LCD and serial interface. A possible method will be to develop the blood pressure monitor with another microcontroller.

5. Develop the program that allow interaction with the internet

The program can have additional feature that allow the interaction with the internet. This allows the user to send the medical information to a doctor. This keep the doctor updated about the health of the user.

6. Develop the program with a blood pressure monitor with downloading capability

The development of the system can be shortened by purchasing a blood pressure monitor with downloading capability.

7.4 Conclusion

The development of the project has encountered many difficulties due to the complication of the microcontroller of the IA2 but the overview of the project is very prospective. The research of the background has concluded that this project is important to promote self-measuring of health for all users and many of the health information requires better presentation to improve the interpretation. Self-measuring of health raise awareness of the user health and improved interpretation of the health information improve diagnosis of the health. Both aims to improve the health of Australians and reduce the cost of medical expense due to cardiovascular disease.

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