SMART WRIST BLOOD PRESSURE MONITORING SYSTEM

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DECLARATION

I hereby declare that the work in the thesis is my own except for quotations and summaries which been duly acknowledged.

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ABSTRACT

Measurement of blood pressure on patients is one of the diagnoses performed in treating patients in hospitals. Oscillometric is one of the common methods used by doctors and nurses to take patients' blood pressure readings. The main objective of this study was to design a small, oscillometric, easy-to-use, and hand-wristwatch tool. In addition, the ocsillometric designed can provide reading information through smart phones. The scope of the study in this project is focused on the construction of a small-sized oscillometric for wristwatch and developing apps apps for smart telephones. The results of this study use PIC as an intermediate oscillometric medium with smart telephones, while the DC 3V motor is used to enable oscillometric operation to operate to obtain blood pressure readings. While MIT software inventor software is used in developing software in smartphones. Finally the project was successfully produced.

Keyword; Blood Pressure,Wrist Blood Pressure

ABSTRAK

Pengukuran tekanan darah terhadap pesakit merupakan salah satu diagnosis yang dilakukan dalam merawat pesakit di hospital. Oscillometric merupakan salah satu kaedah yang biasa digunakan oleh doktor dan jururawat dalam mengambil bacaan tekanan darah pesakit. Objektif utama kajian ini dilakukan adalah untuk merekabentuk sebuah alat oscillometric bersaiz kecil, mudah dipakai dan digunakan dipergelangan tangan pesakit. Selain dari itu ocsillometric yang direkabentuk dapat memberi maklumat bacaan melalui smart phone. Skop kajian dalam projek ini adalah tertumpu kepada pembinaan sebuah oscillometric bersaiz kecil untuk kegunaan dipergelangan tangan dan membangunkan aplikasi apps untuk telifon pintar. Hasil kajian ini menggunakan PIC sebagai medium perantaraan oscillometric dengan telifon pintar, Manakala motor DC 3V digunakan untuk membolehkan oscillometric beroperasi mengendali untuk mendapatkan bacaan tekanan darah. Manakala perisian MIT apps inventor digunakan dalam membangunkan perisian dalam telifon pintar. secara keseluruhan projek ini berjaya dihasilkan.

Kata Kunci ; Pengukutar Tekanan Darah, Pemantauan Tekanan Darah pergelangan tangan

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LIST OF ABBREVIATIONS

mmHg	Millimeter Of Mercury
Bpm	Heart Beats Per Minute
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

According to Barnason, Susan, et al. "Clinical Practice Guideline: Non-Invasive Blood Pressure Measurement with Automated Devices." (2012), Blood pressure (BP) is a core vital sign used as a basis for diagnosis, management and treatment of patients. Clinical measurement of blood pressure can be accomplished both invasively and non-invasively.

However, invasive blood pressure techniques are not usually available during the patient's in the Intensive Care Unit (ICU). Because of that, they will use non-invasive Oscillometric method blood pressure as the standard reference by which other methods are evaluated. Oscillometric method is usually automatic electronic blood pressure, it usually measure from the upper arm of a patient [1]. Therefore even user like nurse have difficulty to go from patience to patience to monitoring their patience blood pressure.

1.2 PROBLEMS STATEMENT

Blood pressure monitoring commonly checked in hospitals using non-invasive automatic electronic blood pressure equipment. This method sometimes takes time especially in the Intensive Care Unit (ICU) or hospital ward, for example nurse need to go patient by patient to monitor and record it manually. Because of that, the schedule for monitoring other patient blood pressure can been delay.

Other than that, it is usually wear on the upper arm, making it when not accurate when unconscious patient sometimes disturb by apply external pressure and sometimes tangling tubing and also moving the position of the cuff. Because of this problem, we need to develop new technology and device to overcome this problem.

1.3 OBJECTIVE

The main objective of this study is:

i. To design smart wrist blood pressure monitoring that can use thru a smart phone.
ii. To develop new smart phone application to monitoring blood pressure
iii. To test the accuracy of the device with other method of blood pressure monitoring

1.4 SCOPE

The scope of this project is to develop a smart wrist blood pressure monitoring especially for ICU patient to measure their blood pressure on their wrist. Hospital staffs such as nurse or doctor can monitor their patient blood pressure on time by connecting thru an application smart phone, they also can sent the result easily. Therefore, this device can overcome the problem that occur.

1.5 SIGNIFICANT OF THE STUDY

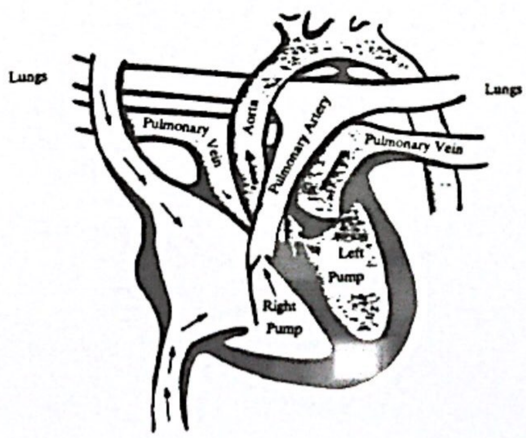
Smart wrist blood pressure will overcome the issues that happened in ICU or ward unit. For example, nurses need to measure and monitor patient blood pressure according to patient schedule, sometimes they late when taking reading because on their busy on other patient. Not only that user can also save patient blood pressure result and sent the result to the doctor easily. As a result, the impact of the device is user friendly, comfortable, tangle free and save time.

CHAPTER 2

LITERATURE REVIEW

2.1 THE CIRCULATORY SYSTEM

The heart is located in the center of the chest, protected by the rib cage. The heart is really a double pump. One pump, the right heart, receives blood which has just come from the body. The right heart, during contraction, pumps the blood to the lungs via the pulmonary artery. The blood then returns to the left heart via the pulmonary vein. This second pump, the left heart, receives the blood from the lungs during contraction, pumps it out through the great artery called the aorta. The aorta branches out to supply the entire body with blood through a series of arteries. Veins are the series of vessels which carry blood from various parts of the body back to the heart. One-way valves in the veins aid the blood on its return trip to the heart. This valve system prevents backward circulation [2].



Figures 2.1: The Heart

2.2 BLOOD PRESSURE

Blood pressure is the pressure of the blood in the arteries as it is pumped around the body by the heart. Systolic blood pressure is the degree of force when the heart is pumping (contracting). The diastolic blood pressure is the degree of force when the hearts relaxed.[2]High blood pressure (hypertension) usually does not have symptoms, but can lead to serious health problems. It is a major risk factor for developing cardiovascular disease, including heart attack and stroke. Healthy eating and lifestyle changes can help to control high blood pressure[3]. Hypotension is therefore a BP that is much lower than usual and which may be causing symptoms such as dizziness or light-headedness.

It is often defined as systolic blood pressure less than 90 mm Hg or diastolic less than 60 mm Hg. A systolic below 100 mm Hg may be more appropriate if the patient normally has hypertension[4].Normal resting systolic (diastolic) blood pressure in an adult is approximately 120 mmHg (80 mmHg), abbreviated "120/80 mmHg". Blood Pressure Measure = Systolic Pressure over Diastolic Pressure

- 120/80 mmHg (Healthy Measurement)
- During Systolic Pressure, Ventricles Contract
- Blood Pressure is Highest During Systole
- During Systolic Pressure, Ventricles Contract
- During Diastolic Pressure Ventricles Relax and Refill
- Blood Pressure is Lowest During Diastole

MAP

Mean Arterial Pressure (MAP)

- Average Pressure Throughout Cardiac Cycle
- MAP = DP + 1/3 (Systolic-Diastolic)

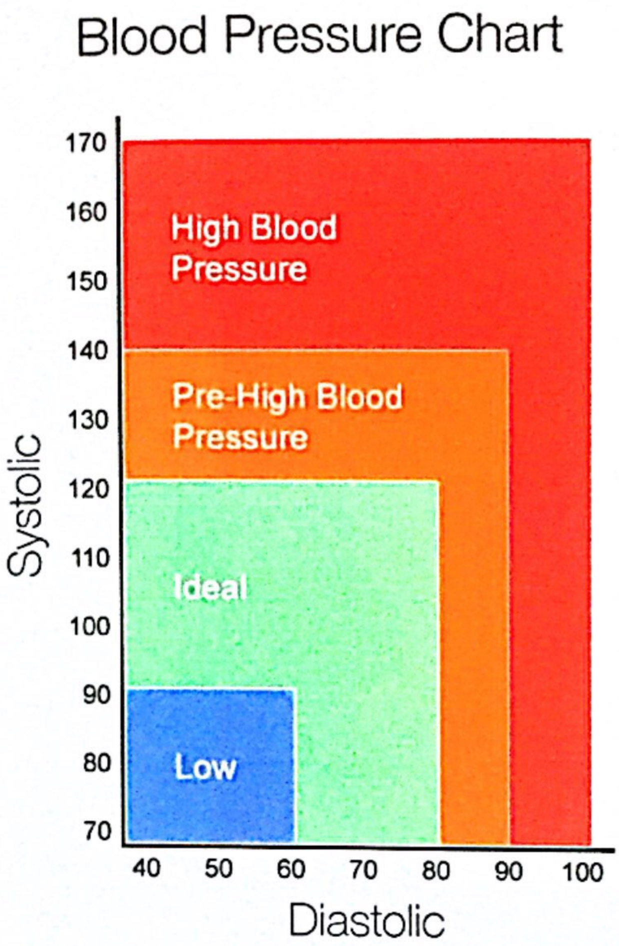


Figure 2.2:Blood Pressure Chart

2.2.1 White Coat Hypertension

Blood pressure measurements by a doctor a lesser extent by a nurse often lead the patient to experience an alerting reaction associated with an increases in blood pressure. White coat hypertension (also referred to as 'office hypertension', or 'isolated clinical hypertension') is a term used to denote individuals who have blood pressures that are higher than normal in the medical environment, but whose blood pressures are normal when they are going about their daily activities[5].

White coat hypertension is a term used for persons not receiving antihypertensive medication who have a persistently high office blood pressure (≥ 140/90 mmHg) together with a normal; ambulatory blood pressure (<135/85 mmHg) or home blood pressure. Muscle sympathetic nerve traffic inhibition coupled with a skin sympathetic nerve traffic excitation induced by measurement of blood pressure by a doctor has been reported to cause the increase in blood pressure. The prevalence of white coat hypertension in older persons is higher than in younger persons and has prevalence rates between 15% and 25% in the elderly. The magnitude of the white coat.effect is increased by older age, female gender, and smoking[6].

2.2.2 Hypertension

High blood pressure is a common condition in which the long-term force of the blood against your artery walls is high enough that it may eventually cause health problems, such as heart disease. .Hypertension is a major risk factor for ischaemic and haemorrhagic stroke, myocardial infarction, heart failure, chronic kidney disease, cognitive decline and premature death. Untreated hypertension is usually associated with a progressive rise in blood pressure. The vascular and renal damage that this may cause can culminate in a treatment-resistant state [7].

High blood pressure is defined as a systolic blood pressure at or above 140 mmHg and/or a diastolic blood pressure at or above 90 mmHg. Systolic blood pressure is the maximum pressure in the arteries when the heart contracts. Diastolic blood pressure is the minimum pressure in the arteries between the heart's contractions. High blood pressure causes the heart to have to work harder to push blood throughout the body. This stresses the body's blood vessels, causing them to stiffen, clog or weaken [8].

2.2.3 Hypotension

Hypotension is therefore a BP that is much lower than usual and which may be causing symptoms such as dizziness or light-headedness. It is often defined as systolic BP less than 90 mm Hg or diastolic BP less than 60 mm Hg. A systolic BP below 100 mm Hg may be more appropriate if the patient normally has hypertension [9].

Fluctuation in blood pressure are a product of normal hemostatic mechanisms and we all experience period when our blood pressure is lower than what is normal for us as individual and that which is consistent with the term "normotensive" (typically 120/80mmhg) [10].

2.3 BLOOD PRESSURE MEASURE METHOD

2.3.1 Invasive Method

Invasive blood pressure (IBP) monitoring usually used technique in the Intensive Care Unit (ICU) and is also often used in the operating theatre. The technique involves the insertion of a catheter into a suitable artery and then displaying the measured pressure wave on a monitor. The cannula must be connected to a sterile, fluid-filled system, which is connected to an electronic pressure transducer The most common reason for using intra-arterial blood pressure monitoring is to gain a 'beat-to-beat' record of a patient's blood pressure". It is the most accurate measurement of the blood pressure but it is also a painful method. The disadvantage of the method is it can cause infection and thrombosis. Not only that, it is also expensive [11].

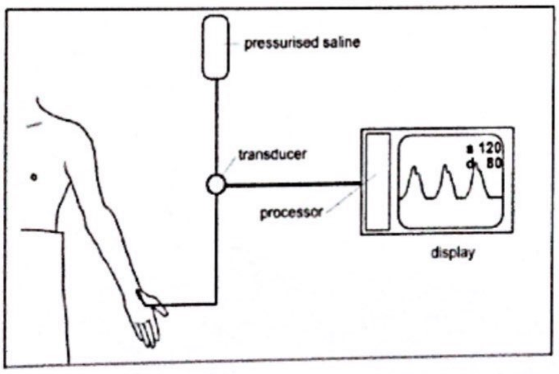


Figure 2.3: Components of an arterial monitoring system

2.3.2 The Auscultatory Method

It is also called Korotkoff technique for measuring blood pressure and it is still continued to be used without any improvement. The brachial artery is occluded by the cuff that placed around the upper arm and then inflated to above systolic pressure. As it slowly deflated, blood flow is can be heard by the sounds that can be detected by a stethoscope held over the artery just below the cuff. Traditionally, the sounds have been classified as 5 phases phase one is appearance of clear tapping sounds corresponding to the appearance of a palpable pulse, then phase 2, sounds become softer and longer; phase 3, sounds become crisper and louder; phase 4, sounds become muffled and softer; and finally phase 5, sounds disappear completely. The fifth phase is thus recorded as the last audible sound [12].

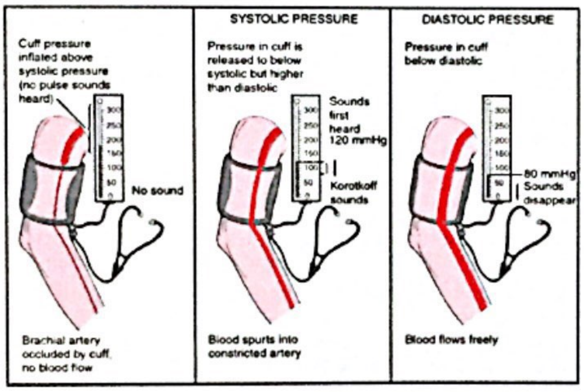


Figure 2.4: Auscultatory Method

2.3.3 Oscillometric Method

Introduce by Marey in year 1876, and it was subsequently shown that when the oscillations of pressure in a sphygmomanometer cuff are recorded cuff slowly deflation, when it is on maximal oscillation corresponds to the mean intra-arterial pressure [13][14]. The oscillations begin at approximately systolic pressure and continue below diastolic, so that systolic and diastolic pressure can only be estimated indirectly according to some empirically derived algorithm.

The advantageous of this method is it that no transducer need be placed over the brachial artery, and it is less susceptible to external noise, and that the cuff can be reuse by the patient. The main disadvantage this method do not work well during physical activity or when when there may be considerable movement artifact move. This oscillometric technique usually use to measure blood pressure monitors and home monitors. It should be pointed out that different brands of oscillometric recorders use different algorithms, and there is no generic oscillometric technique.

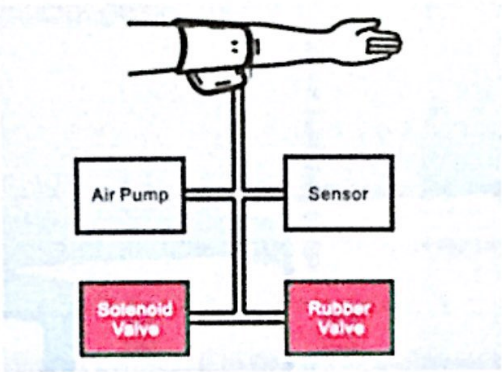


Figure 2.5: Oscillometric method block diagram

2.3.4 The Finger Cuff Method of Penaz

This method was first introduced by Penaz and works on the principle of the unloaded arterial wall. Arterial pulsation in a finger is detected by a photoplethysmo graph under a pressure cuff. The output of the plethysmograph is used to drive a servo loop, which rapidly changes the cuff pressure to keep the output constant, so that the artery is held in a partially opened state [15].

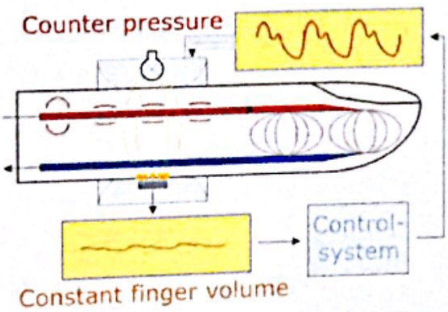


Figure 2.6: Finger Cuff Method of Penaz block diagram

2.3.5 Ultrasound Techniques

Devices use together with this technique use an ultrasound transmitter and receiver placed below the brachial artery under of a cuff. As the cuff is deflated, the movement of the arterial wall at systolic pressure causes a Doppler phase shift in the reflected ultrasound, and diastolic pressure is recorded as the point at which diminution of arterial motion occurs.

In patients with very faint Korotkoff sounds (for example those with muscular atrophy), placing a Doppler probe over the brachial artery may help to detect the systolic pressure, and the same technique can be used for measuring the ankle–arm index, in which the systolic pressures in the brachial artery and the posterior tibial artery are compared to obtain an index of peripheral arterial disease [16].

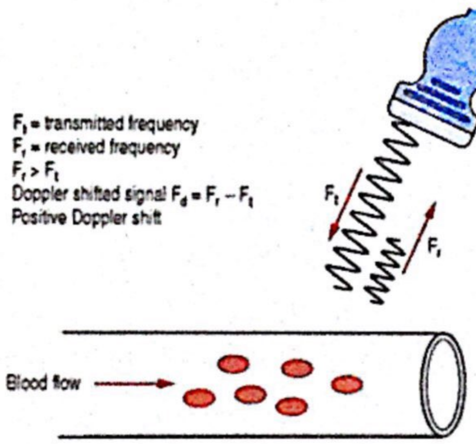


Figure 2.7: Ultrasound technique measuring

2.3.6 Tonometry

This technique is when an artery is partially compressed or splinted against a bone, the pulsations are proportional to the intra-arterial pressure. This has been developed for measurement of the blood pressure at the wrist, because the radial artery lies just over the radius bone[17]. However, the transducer needs to be situated directly over the center of the artery. Hence, the signal is very position sensitive.

This has been dealt with by using an array of transducers placed across the artery. Although the technique has been developed for beat to beat monitoring of the wrist blood pressure, it requires calibration in each patient and is not suitable for routine clinical use.

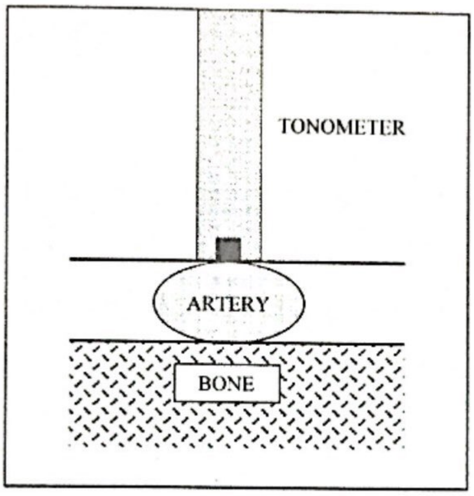


Figure 2.8: Tomometer

2.4 LOCATION OF BLOOD PRESSURE MONITORING

2.4.1 Arm

The standard location for blood pressure measurement is the upper arm, with the stethoscope at the elbow crease over the brachial artery, although there are several other sites where it can be performed. Monitors that measure pressure at the wrist and fingers have become popular, but it is important to realize that the systolic and diastolic pressures vary substantially in different parts of the arterial tree.

In general, the systolic pressure increases in more distal arteries, whereas the diastolic pressure decreases. Mean arterial pressure falls by only 1 to 2 mm Hg between the aorta and peripheral arteries [18]

2.4.2 Wrist

Wrist monitors have the advantages of being smaller than the arm devices and can be used in obese people, because the wrist diameter is little affected by obesity. A potential problem with wrist monitors is the systematic error introduced by the hydrostatic effect of differences in the position of the wrist relative to the heart.

This can be avoided if the wrist is always at heart level when the readings are taken, but there is no way of knowing retrospectively whether this was performed when a series of readings are reviewed. Devices are now available that will only record a measurement when the monitor is held at heart level. Wrist monitors have potential but need to be evaluated further.[19]

2.4.3 Finger

Finger monitors have so far been found to be inaccurate and are not recommended.[20]

CHAPTER 3

METHODOLOGY

3.1 FLOW CHART

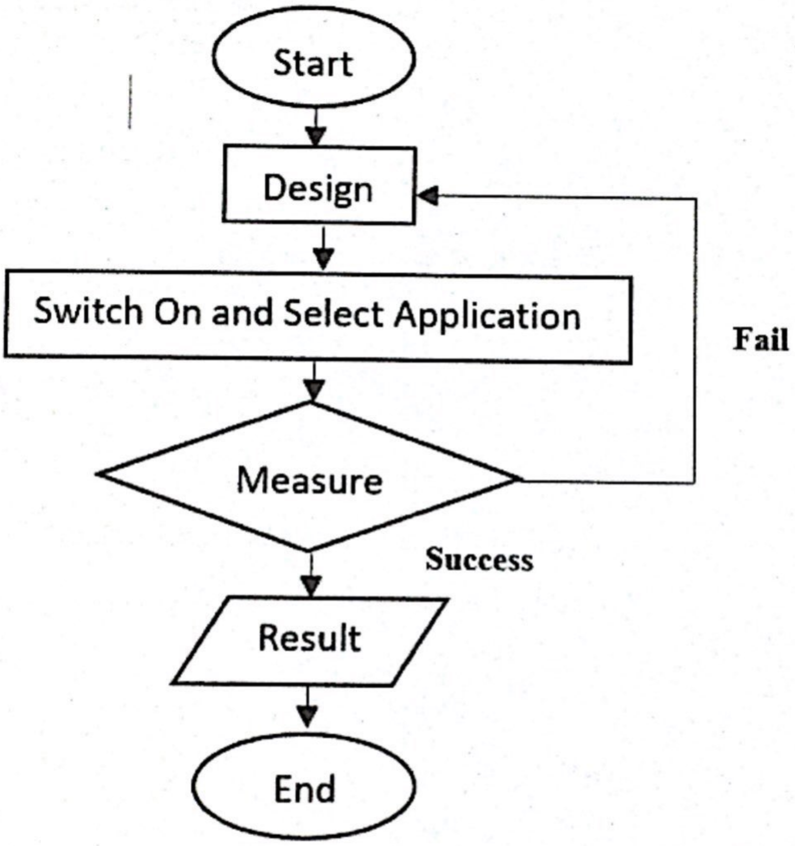


Figure : 3.1 Flow Chart of Project

3.2 BLOCK DIAGRAM

To develop this project, there were involve of software and hardware such as PIC16F877A, DC Motor Pump, Bluebee, mikroC, MIT Apps Inventor and many more. Refer to figure 3.2 below is the example of block diagram of the hardware operates.

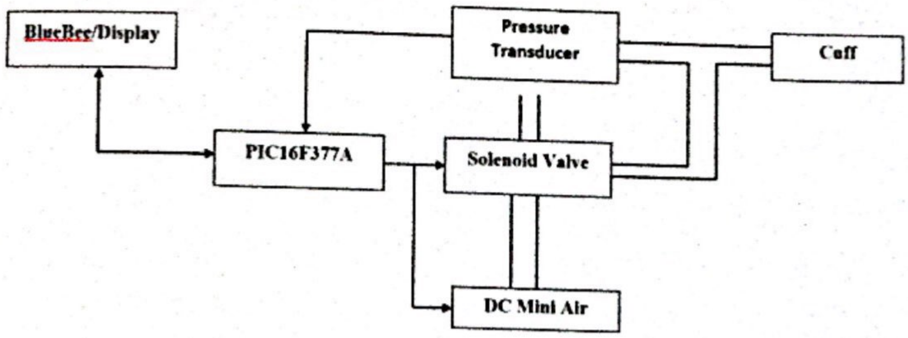


Figure 3.2: Block Diagram

3.3 HARDWARE

In this project, the hardware has been used are PIC16F877A, Pressure Transduser, DC Mini Motor Pump, Dump Valve, and Cyctron BlueBee

3.3.1 PIC16F877A

PIC (usually pronounced as "pick") is a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Peripheral Interface Controller. The manufacturer supplies computer software for development known as MPLAB, assemblers and C/C++ compilers, and programmer/debugger hardware under the MPLAB and PICKit series. Third party and some open-source tools are also available.

Some parts have in-circuit programming capability; low-cost development programmers are available as well as high-production programmers. PIC devices are popular with both industrial developers and hobbyists due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, serial programming, and re-programmable Flash-memory capability.

In this project will use PIC16F877A because it is easier to program and common to use. It will control the device follow from the command that has been program inside. Microcontroller act as a central processor to control the pump, pressure transducer, deflate and inflate valve, Bluebeewireless and LCD.These various pin functions cannot be used simultaneously, but can be changed at any point during operation. The figure 3.3 show where is the location of each pin and table 3.1 below have descripted every single function which contained in each of the pins

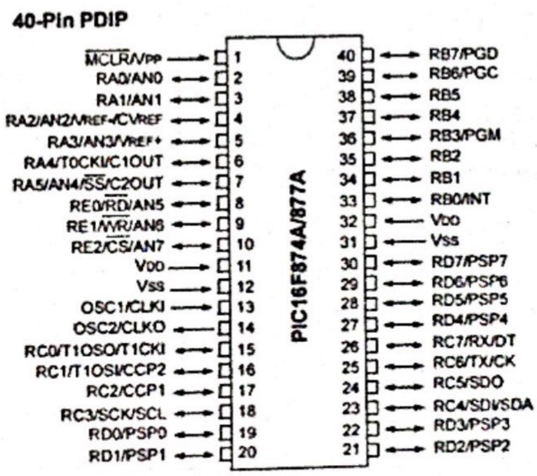


Figure 3.3: PIC16F877A

Table 3.1 have descripted the Pin 13 until Pin 26, most of the pins are multi-function, except the Port D pins, which this 4 pins are only function as Input or Output.

Table 3.1: PIC16F877A Pin Assignment

Name	Number (DIP 40)	Function	Description
RE3/MCLR/Vpp	1	RE3	General purpose input Port E
		MCLR	Reset pin. Low logic level on this pin resets microcontroller.
		Vpp	Programming voltage
RA0/AN0/ULPWU/C12IN0-	2	RA0	General purpose I/O port A
		AN0	A/D Channel 0 input
		ULPWU	Stand-by mode deactivation input
		C12IN0-	Comparator C1 or C2 negative input
RA1/AN1/C12IN1-	3	RA1	General purpose I/O port A
		AN1	A/D Channel 1
		C12IN1-	Comparator C1 or C2 negative input
RA2/AN2/Vref-/CVref/C2IN+	4	RA2	General purpose I/O port A
		AN2	A/D Channel 2
		Vref-	A/D Negative Voltage Reference input
		CVref	Comparator Voltage Reference Output
		C2IN+	Comparator C2 Positive Input
RA3/AN3/Vref+/C1IN+	5	RA3	General purpose I/O port A
		AN3	A/D Channel 3
		Vref+	A/D Positive Voltage Reference Input
		C1IN+	Comparator C1 Positive Input
RA4/T0CKI/C1OUT	6	RA4	General purpose I/O port A
		T0CKI	Timer T0 Clock Input
		C1OUT	Comparator C1 Output
RA5/AN4/SS/C2OUT	7	RA5	General purpose I/O port A
		AN4	A/D Channel 4
		SS	SPI module Input (*Slave Select*)
		C2OUT	Comparator C2 Output
RE0/AN5	8	RE0	General purpose I/O port E
		AN5	A/D Channel 5
RE1/AN6	9	RE1	General purpose I/O port E
		AN6	A/D Channel 6
RE2/AN7	10	RE2	General purpose I/O port E
		AN7	A/D Channel 7
Vdd	11	+	Positive supply
Vss	12	-	Ground (GND)

Table 3.2 have descripted the Pin 13 until Pin 26, most of the pins are multi-function, except the Port D pins, which this 4 pins are only function as Input or Output.

Table 3.2: cont. PIC16F877A Pin Assignment

Name	Number (DIP 40)	Function	Description
RA7/OSC1/CLKIN	13	RA7	General purpose I/O port A
		OSC1	Crystal Oscillator Input
		CLKIN	External Clock Input
RA6/OSC2/CLKOUT	14	OSC2	Crystal Oscillator Output
		CLKO	Fosc/4 Output
		RA6	General purpose I/O port A
RC0/T1OSO/T1CKI	15	RC0	General purpose I/O port C
		T1OSO	Timer T1 Oscillator Output
		T1CKI	Timer T1 Clock Input
RC1/T1OSO/T1CKI	16	RC1	General purpose I/O port C
		T1OSI	Timer T1 Oscillator Input
		CCP2	CCP1 and PWM1 module I/O
RC2/P1A/CCP1	17	RC2	General purpose I/O port C
		P1A	PWM Module Output
		CCP1	CCP1 and PWM1 module I/O
RC3/SCK/SCL	18	RC3	General purpose I/O port C
		SCK	MSSP module Clock I/O in SPI mode
		SCL	MSSP module Clock I/O in I^2C mode
RD0	19	RD0	General purpose I/O port D
RD1	20	RD1	General purpose I/O port D
RD2	21	RD2	General purpose I/O port D
RD3	22	RD3	General purpose I/O port D
RC4/SDI/SDA	23	RC4	General purpose I/O port A
		SDI	MSSP module *Data* input in SPI mode
		SDA	MSSP module *Data* I/O in I^2C mode
RC5/SDO	24	RC5	General purpose I/O port C
		SDO	MSSP module *Data* output in SPI mode
RC6/TX/CK	25	RC6	General purpose I/O port C
		TX	USART Asynchronous Output
		CK	USART Synchronous Clock
RC7/RX/DT	26	RC7	General purpose I/O port C
		RX	USART Asynchronous Input
		DT	USART Synchronous Data

From the table 3.3, its show the pin from 27 until the last pin which is the pins 40. From the table above, pins 31 and pin 32 are same function as the pin 11 and pin 12 which are function as positive supply and also Ground (GND). Refer the table above are needed before decided which pins are used and it can only function as follow the pins specific function.

Table 3.3: cont. PIC16F877A Pin Assignment

Name	Number (DIP 40)	Function	Description
RD4	27	RD4	General purpose I/O port D
RD5/P1B	28	RD5	General purpose I/O port D
		P1B	PWM Output
RD6/P1C	29	RD6	General purpose I/O port D
		P1C	PWM Output
RD7/P1D	30	RD7	General purpose I/O port D
		P1D	PWM Output
Vss	31	-	Ground (GND)
Vdd	32	+	Positive Supply
RB0/AN12/INT	33	RB0	General purpose I/O port B
		AN12	A/D Channel 12
		INT	External Interrupt
RB1/AN10/C12INT3-	34	RB1	General purpose I/O port B
		AN10	A/D Channel 10
		C12INT3-	Comparator C1 or C2 Negative Input
RB2/AN8	35	RB2	General purpose I/O port B
		AN8	A/D Channel 8
RB3/AN9/PGM/C12IN2-	36	RB3	General purpose I/O port B
		AN9	A/D Channel 9
		PGM	Programming enable pin
		C12IN2-	Comparator C1 or C2 Negative Input
RB4/AN11	37	RB4	General purpose I/O port B
		AN11	A/D Channel 11
RB5/AN13/T1G	38	RB5	General purpose I/O port B
		AN13	A/D Channel 13
		T1G	Timer T1 External Input
RB6/ICSPCLK	39	RB6	General purpose I/O port B
		ICSPCLK	Serial programming Clock
RB7/ICSPDAT	40	RB7	General purpose I/O port B
		ICSPDAT	Programming enable pin

3.3.2 Pressure transducer (MPXV5050GP CASE 1369-01)

The MPXV5050G series piezoresistive transducer is a state-of-theart monolithic silicon pressure sensor designed for a wide range of applications, but particularly those employing a microcontroller or microprocessor with A/D inputs. This patented, single element transducer combines advanced micromachining techniques, thin-film metallization, and bipolar processing to provide an accurate, high level analog output signal that is proportional to the applied pressure. This transducer has been program to count and measure the change of pressure from the cuff and deliver it back to PIC to calculate the reading for diastolic, systolic and heartrate. Figure 3.4 show the physical unit of the pressure sensor.

Figure 3.4: Pressure Transducer

3.3.3 3V DC KOGE MINI PUMP KPM14A

This is a 3V DC mini electric pressure pump. It has been used widely, like blood pressure monitors, various instruments, medical application, automatic machine assembly and vary kinds of machinery. Air is sucked into the pump from two vents on either side and blown out through the nozzle. Air blows out even if the motor is reversed. Figure 3.5 show the physical unit of the DC Motor Mini Pump.

Figure 3.5: DC Motor Mini Pump

3.3.4 DUMP VALVE (3V DC AIR RELEASE VALVE KOGE)

It act as air flow control to the cuff. It block and release air flow that been control by PIC. It will connect to the tube that connect to the pump and pressure sensor. Figure 3.6 show the physical unit of the Dump Valve.

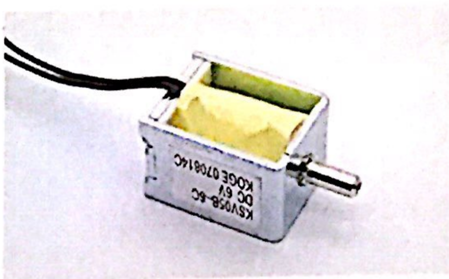


Figure 3.6: Dump Valve

3.3.5 Cytron Bluebee

BlueBee is Bluetooth wireless module from Cytron Technologies which is design to adapt from factor of XBee module. The pinout of BlueBee is compatible with XBEE which is suitable for all kinds of microcontroller systems that have 3.3V power out. There are 2 modes on BlueBee which is Transfer mode and AT mode. The baudrate of module may be set using AT commands/mode. The BlueBee module comes with an on-board antenna, the antenna provides better signal quality. It acts like a transparent serial port, which works with a variety of Bluetooth adapter and Bluetooth phone. The BlueBee is only slave module. Communication among two BlueBee is not possible. BlueBee act as wireless that transmit and receive data and result from Arduino to android smart phone. Figure 3.7 show the physical unit of the BlueBee.

Features

- 2.5% Maximum Error over 0° to 85°C
- Ideally suited for Microprocessor or Microcontroller-Based Systems
- Temperature Compensated Over –40° to +125°C
- Patented Silicon Shear Stress Strain Gauge
- Durable Epoxy Unibody Element
- Easy-to-Use Chip Carrier Option

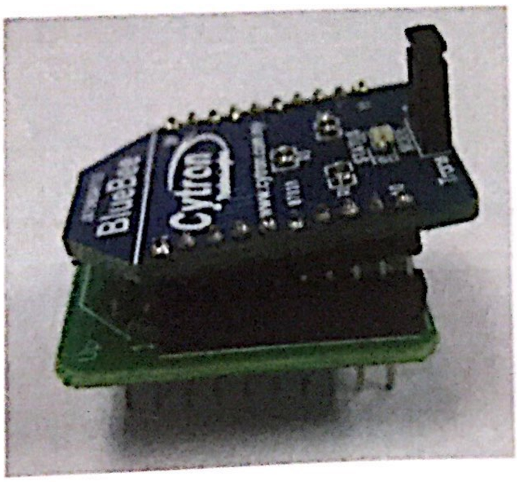


Figure 3.7: BlueBee

3.4 SOFTWARE

The software has been used in this project are Cadsoft Eagle, MIT Apps Inventor, mikroC, Pic Kit 2 Programming kit, and Microsoft Excel.

3.4.1 Cadsoft Eagle

EAGLE is a scriptable electronic design automation application with schematic capture, printed circuit board layout, auto-router and computer-aided manufacturing features. EAGLE contains a schematic editor, for designing circuit diagrams. Parts can be placed on many sheets and connected together through ports. Before etching, we must plan a design of schematic board which contain component that we want to include inside the board. Figure 3.8 show the interface of the Cadsoft Eagle.

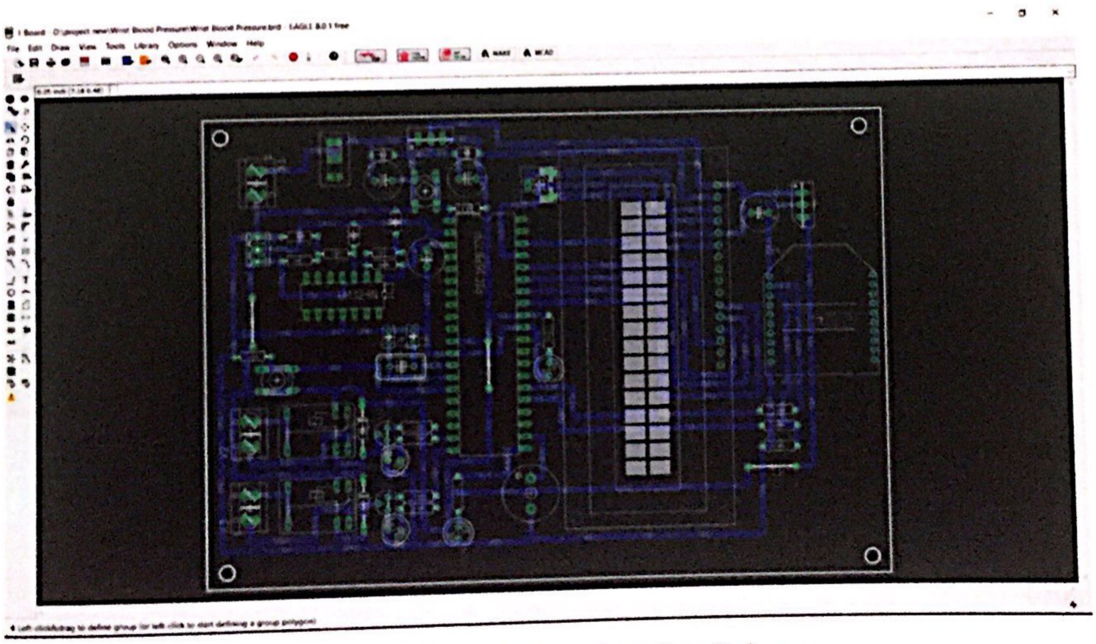


Figure 3.8: Cadsoft Eagle Interface Software

3.4.2 MIT Apps Inventor

MIT App Inventor is an innovative beginner's introduction to programming and app creation that transforms the complex language of text-based coding into visual, drag-and-drop building blocks. The simple graphical interface grants even an inexperienced novice the ability to create a basic. It allows newcomers to computer programming to create software applications for the Android operating system (OS). It uses a graphical interface, very similar to Scratch and the StarLogo TNG user interface, which allows users to drag-and-drop visual objects to create an application that can run on Android devices. In creating App Inventor, Google drew upon significant prior research in educational computing, as well as work done within Google on online development environments. Figure 3.9 show the interface of the MIT apps website.

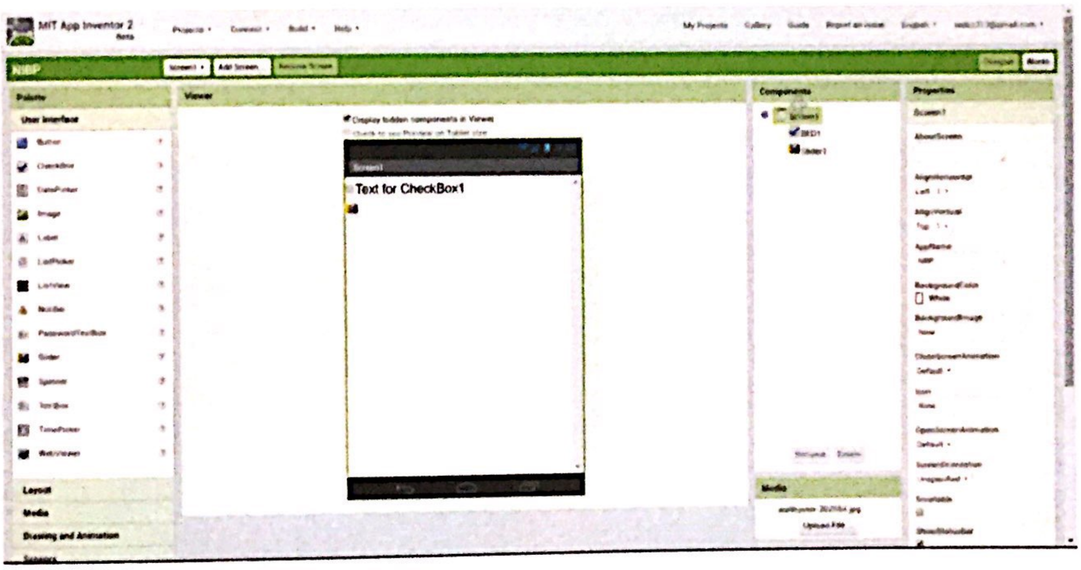


Figure 3.9: MIT Apps Inventor

3.4.3 mikroC

The mikroC is for PIC development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control. PIC and C fit together well: PIC is the most popular 8-bit chip in the world, used in a wide variety of applications, and C, prized for its efficiency, is the natural choice for developing embedded systems. mikroC PRO for PIC provides a successful match featuring highly advanced IDE, ANSI compliant compiler, broad set of hardware libraries, comprehensive documentation, and plenty of ready-to-run examples. The program from mikroC will be stored inside the PIC16F877A for the PIC to operate to from the command.Contains a text editor for writing code, a message Area, a text Console, a toolbar with buttons for common functions and a Series of menus. For this project it is use to upload the programming to HEX file to PIC to control all the component. . Figure 3.10 show the interface of the MikroC software.

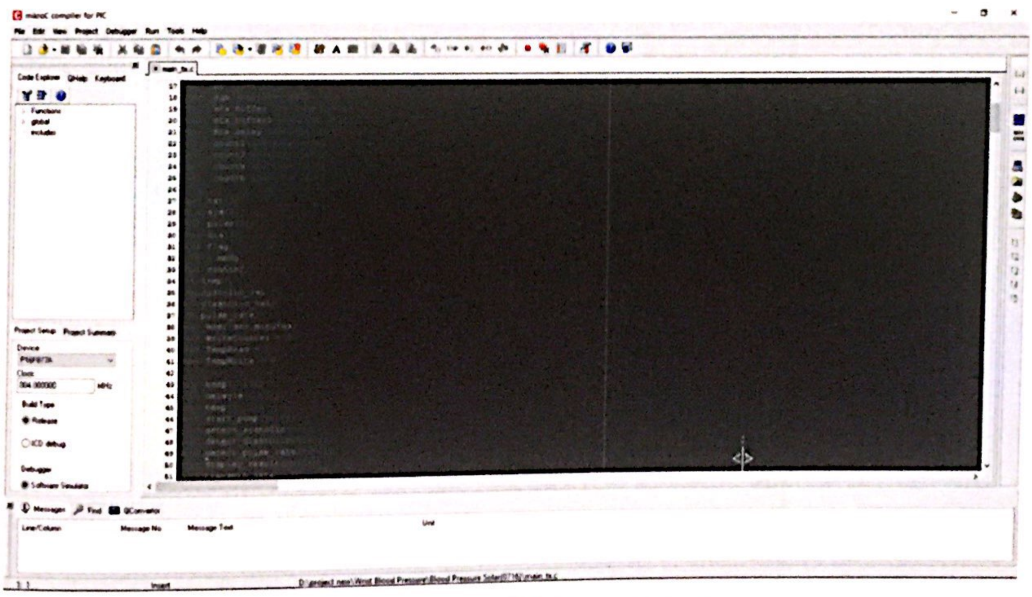


Figure 3.10: MikroC Software Interface

3.4.4 Microchip PIC KIT 2 microcontroller programmer

The PICkit 2 Development Programmer/Debugger (PG164120) is a development tool with an easy to use interface for programming and debugging Microchip's Flash families of microcontrollers. The full featured Windows programming interface supports baseline (PIC10F, PIC12F5xx, PIC16F5xx), midrange (PIC12F6xx, PIC16F), PIC18F, PIC24, dsPIC30, dsPIC33, and PIC32 families of 8-bit, 16-bit, and 32-bit microcontrollers, and many Microchip Serial EEPROM products. With Microchip's powerful MPLAB Integrated Development Environment (IDE) the PICkit 2 enables in-circuit debugging on most PIC® microcontrollers. In-Circuit-Debugging runs, halts and single steps the program while the PIC microcontroller is embedded in the application. When halted at a breakpoint, the file registers can be examined and modified. Figure 3.11 show the interface of the PICkit 2 software.

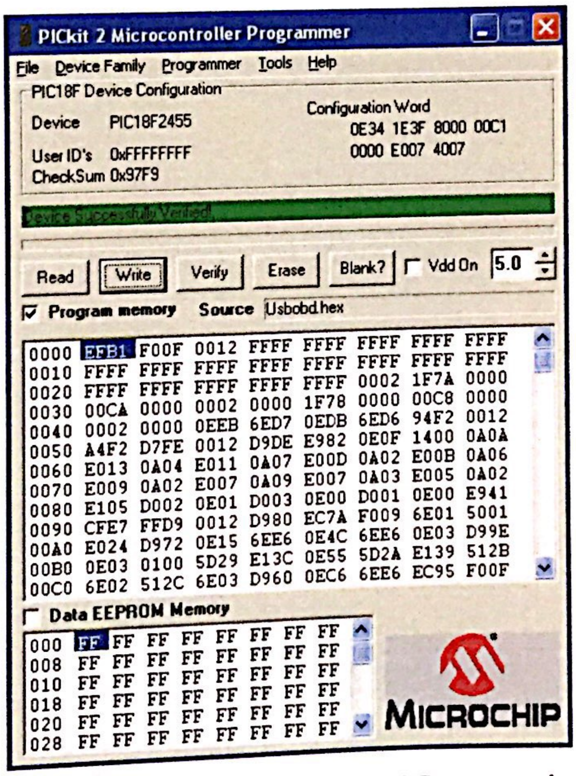


Figure 3.11 Micro Chip PIC KIT 2 Programming

3.4.5 PIC Programmer Kit

Compile the programming code that have wrote by click on 'Build All' which to checking the code completely non error to be loaded into the PIC. If there is error occur, identify the error and corrected the error. After that, compile the programming again, and make sure there is no error occur. And then, load the programming into PIC by using PIC Programmer Kit. PIC Programmer Kit is shown in the figure 3.12.

After the programming have load into the PIC16F877A, attached the PIC into the PCB boards that have done, and connected with the motor and batteries for testing the programming. If the output testing is not the desired output which means testing failed. Return to the step of writing programming, execute the programming and load the programming into PIC16F877A, then re-testing the programming. If no failed, attached the PIC into the PCBs then proceed to the data collection.

Figure 3.12 PIC Programming Burner

3.5 PROJECT COSTING

Overall costing of the project is RM417.50 to develop this project. Mainly use dor hardware only/

Table 3.4 Overall Costing

ITEM	PRICE (RM)	UNIT	TOTAL (RM)
PIC16F877A	12.00	1	12.00
Dc Mini Motor Pump	15.00	1	15.00
Pressure Transducer	250.00	1	250.00
Dump Valve	65.00	1	65.00
2N3094 transistor	0.50	1	0.50
Wire	2.00	1	2.00
Cuff	40.00	1	40.00
3-way Valve	15.00	1	15.00
2-way Valve	13.00	1	13.00
Bluetooth Kit (BlueBee)	65.00	1	65.00
Tubing	5.00	1	5.00
TOTAL			**RM417.50**

CHAPTER 4

RESULT AND DISCUSION

4.1 INTRODUCTION

This chapter showed the result from data collection such as data analyzed and generated graph and value by using excel. And then the result will be discussed in this chapter. As been mention before, the purpose of this project is to innovate the non invasive and continuous blood pressure. The device will be compare result from the upper arm that usually use at the hospital.

4.2 SMART WRIST BLOOD PRESSURE MONITORING DEVICE

Figure below show that the actual device. It can measure blood pressure from hand wrist. It can measure Systolic, Diastolic in mmHg and Heart Rate in beat per minute then display the result on LCD. Not only that, the device also can sent the result thru Bluetooth to an android smart phone from a distance.

Other than that, this device has cuff that is snap on to the wrist. It will inflate as it start measure and the slowly deflate when it start taking reading of systolic, diastolic and heart rate. The device can use either 9V battery or 9V AC adapter.

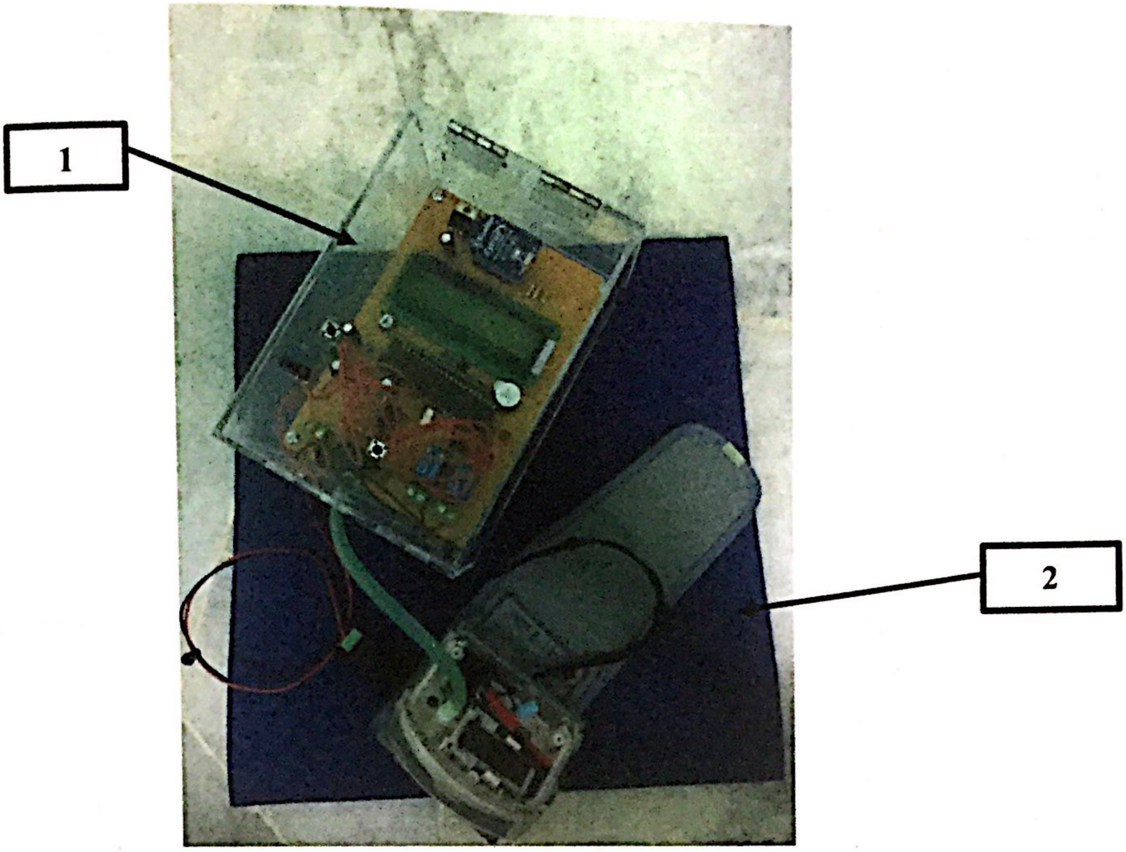


Figure 4.1 Smart Wrist Blood Pressure Device

Table 4.1 Main function of the device

NO	PART	FUNCTION
1	Control Panel	Switch On and Control the device
2	Cuff	Inflate and Deflate to measure the blood pressure

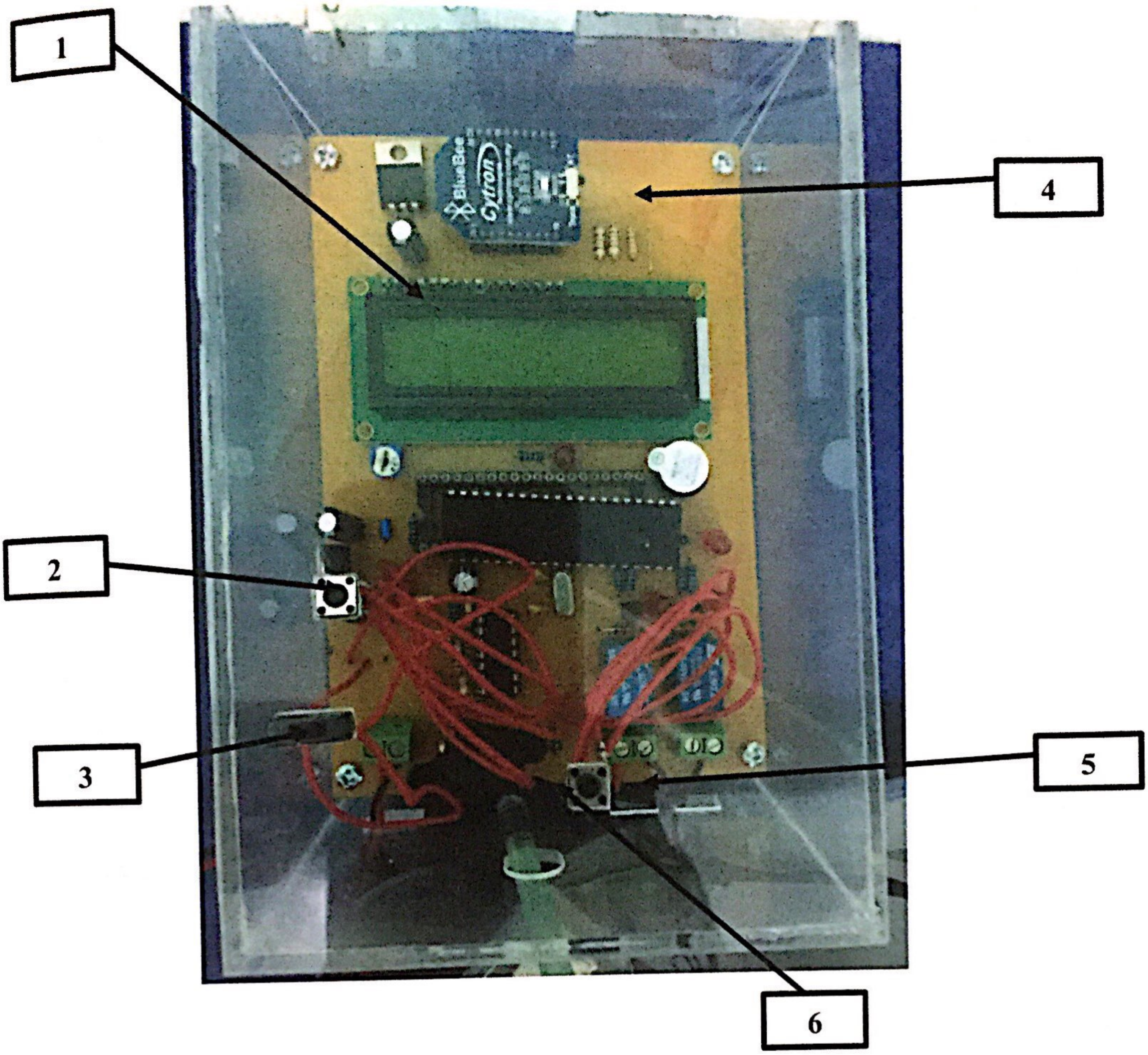


Figure 4.2 Smart Wrist Blood Pressure Device (Control Panel)

Table 4.2 Function of the Control Panel

NO	PART	FUNCTION
1	LCD	Display reading
2	Reset Button	To reset all the system to take another reading
3	Switch	On and Off the device
4	BlueBee Bluetooth	To send result to smartphone thru Bluetooth
5	Start Button	To start taking reading
6	Pressure sensor	To measure sensor

4.3 WRIST BLOOD PRESSURE APPLICATION

Figure 4.3 below show the application that has been installed on android smart phone. The application has 1 selection button which is connect and disconnect button to the Bluebee. The application will show 3 results that has been received from the bluebee which is the Systolic, Diastolic and Heart Rate. Figure 4.3 show how the application looks like and table 4.3 show what the function of each part.

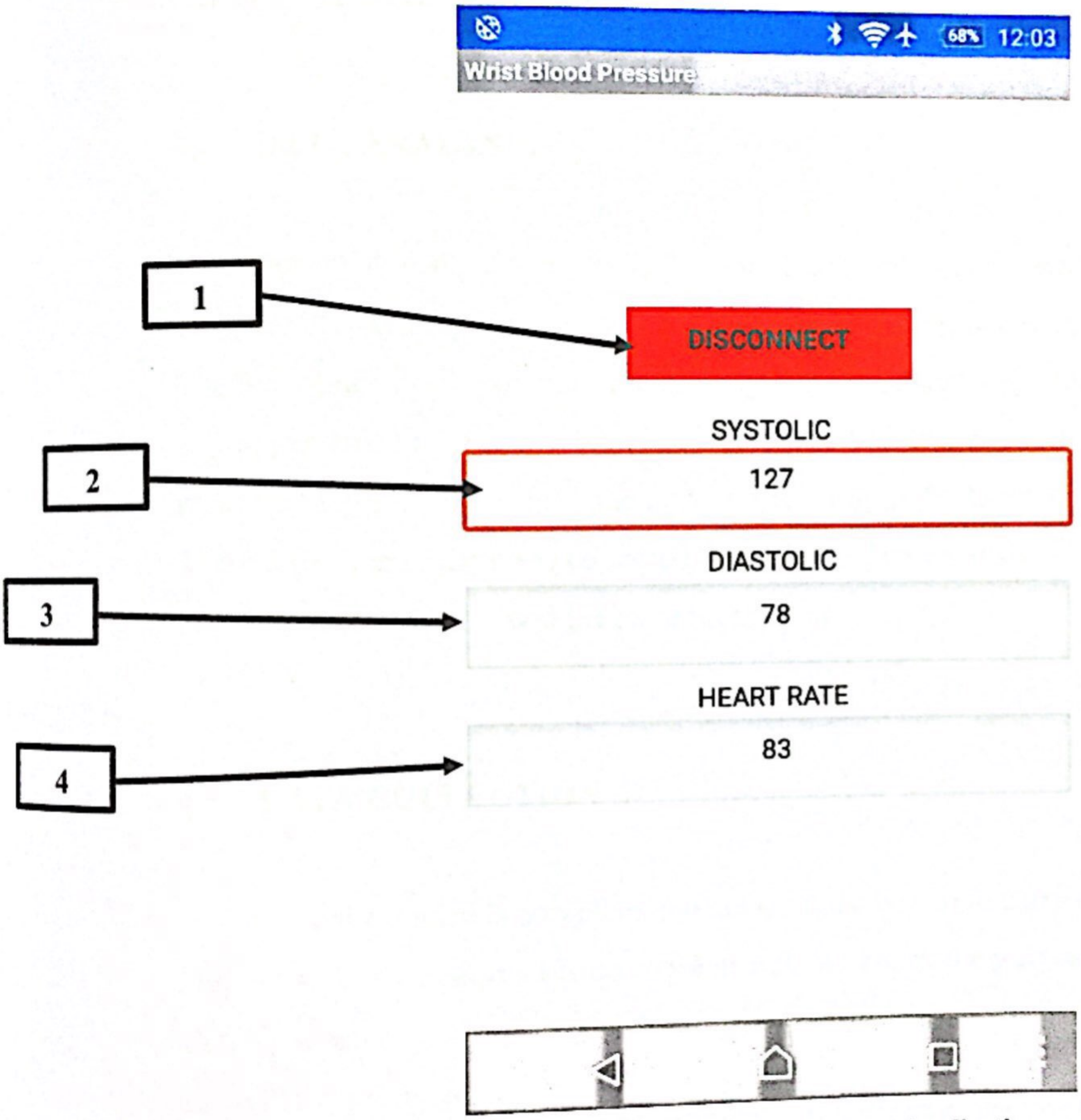


Figure 4.3 Wrist Blood Pressure Application

Table 4.3 Function of the Application

NO	PART	FUNCTION
1	Connect/Disconnect	Bluetooth Connection to BlueBee
2	Systolic Reading	Display Systolic Reading
3	Diastolic Reading	Display Diastolic Reading
4	Heart Rate Reading	Display Heart Rate Reading

4.4 DATA ANALYSIS

During this data analysis, 20 normal subjects were tested to them. Reading compare between 3 parameter which is systolic pressure, diastolic pressure, and heart. The 3 parameter will compare the reading between smart wrist blood pressure device and upper arm blood pressure. The subject need to rest about 3 to 5 minutes before measure their reading to give the accurate reading as the heart slowly rest to normal.. These 3 parameter data was collected through the data analysis, which the subject have tested the smart wrist blood pressure monitoring.

4.5 DATA COLLECTION

Once the device is complete, the device must be test to carry out on the product to find out whether a product is accurate or not. Whereas, the purpose of this testing was identify whether the product is accurate as the existing upper arm blood pressure. The test will be conducted to test the effectiveness of several people for the device. Table 4.3 below shows the result that already been taken from 20 subject. Systolic, diastolic, and heart rate result has been recorded. Other than that by comparing both result then calculate both result to get the percentage error.

$$Percentage\ of\ Error = \frac{Upper\ Arm\ Value - Wrist\ Value}{Upper\ Arm\ Value} \times 10$$

$$Percentage\ of\ Error = \frac{128 - 118}{128} \times 100$$

$$Percentage\ of\ Error = \frac{10}{128} \times 100 = 7.8\%$$

Table 4.4 Comparison of Upper Arm and Wrist Blood Pressure Reading

Subject	Upper Arm Blood Pressure Monitoring			Smart Wrist Blood Pressure Minitoring		
	Blood Pressure (mmHg)		Heart Rate (Bpm)	Blood Pressure (mmHg)		Heart Rate (Bpm)
	Systolic	Diastolic		Systolic	Diastolic	
1	124	77	71	122	75	81
2	101	79	92	111	76	83
3	120	82	90	124	81	80
4	109	70	76	112	76	79
5	112	80	69	120	78	79
6	126	70	92	124	76	83
7	124	79	87	124	81	82
8	99	62	62	110	71	76
9	120	81	87	125	75	82
10	127	86	90	121	82	84
11	111	76	79	118	78	83
12	125	81	70	124	80	79
13	100	73	94	112	75	84
14	119	83	70	126	74	78
15	123	87	61	126	82	69
16	106	67	66	116	71	76
17	110	72	64	121	79	70
18	121	82	77	126	80	82
19	124	81	87	126	77	83
20	119	78	61	123	79	60

4.5.1 Systolic

Table 4.5 below show that the comparison of systolic upper arm and wrist blood pressure. The different between both readings is between ± 15 millimeters of mercury (mmHg). Then using the formula for percentage error, the lowest that has been calculate is 0% and the highest is 12%. From the table reading a graph has plotted. Figure 4.4 show the graph comparison of the systolic reading between two readings. Figure 4.5 show the percentage error for each subject.

Table 4.5 Systolic Upper Arm and Wrist Comparison

Subject	Upper Arm	Wrist	Percentage Error (%)
1	124	122	1.61
2	101	111	9.90
3	120	124	3.33
4	109	112	2.75
5	112	120	7.14
6	126	124	1.59
7	124	124	0.00
8	99	110	11.11
9	120	125	4.17
10	127	121	4.72
11	111	118	6.31
12	125	124	0.80
13	100	112	12.00
14	119	126	5.88
15	123	126	2.44
16	106	116	9.43
17	110	121	10.00
18	121	126	4.13
19	124	126	1.61
20	119	123	3.36

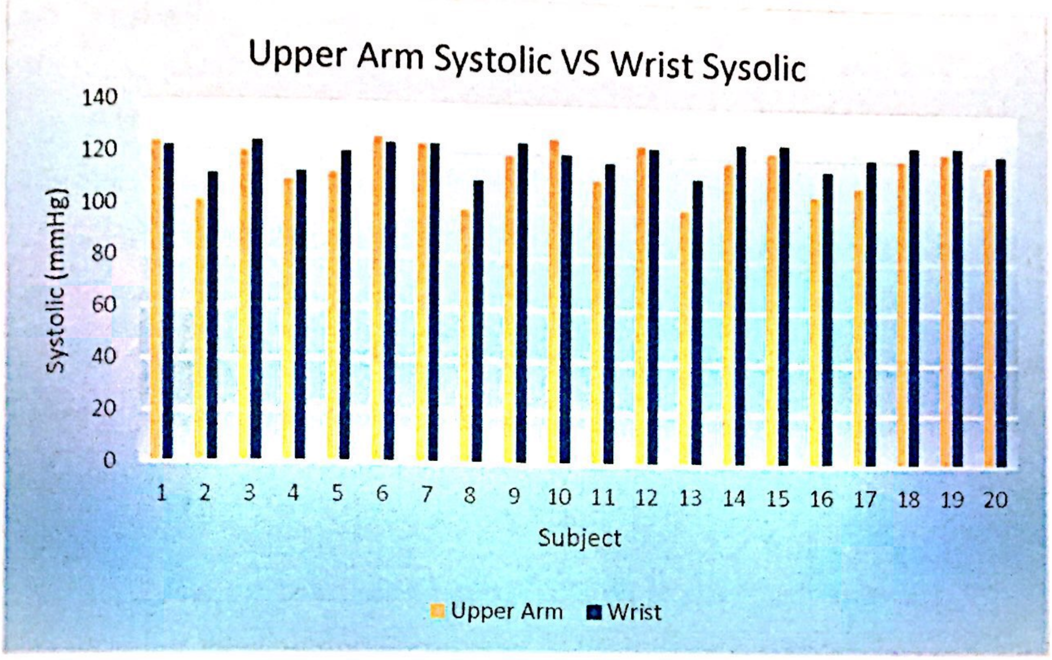


Figure 4.4 Upper arm and Wrist Blood Pressure Systolic Comparison

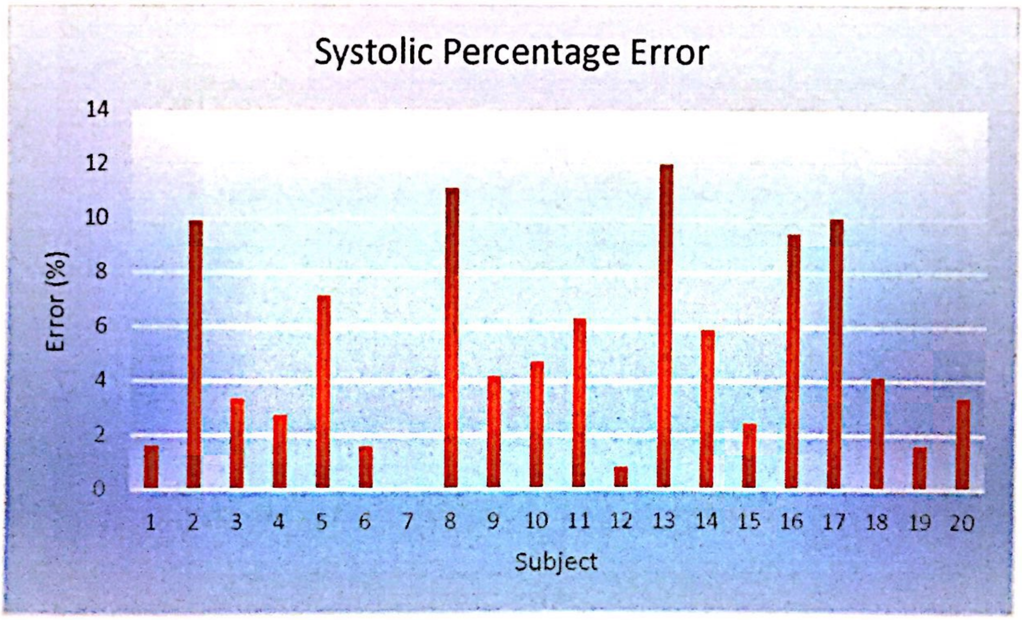


Figure 4.5 Systolic Percentage Error

4.5.2 Diastolic

Meanwhile, Table 4.6 below show that the comparison of diastolic upper arm and wrist blood pressure. The different between both readings is between ± 12 millimeters of mercury (mmHg). Then using the formula for percentage error, the lowest that has been calculate is 1% and the highest is 14.52%. From the table reading a graph has plotted. Figure 4.6 show the graph comparison of the systolic reading between two readings. Figure 4.7 show the percentage error for each subject.

Table 4.6 Diastolic Upper Arm and Wrist Comparison

Subject	Upper Arm	Wrist	Percentage Error (%)
1	77	75	2.60
2	79	76	3.80
3	82	79	3.66
4	70	76	8.57
5	80	78	2.50
6	70	76	8.57
7	79	81	2.53
8	62	71	14.52
9	81	75	7.41
10	86	82	4.65
11	76	78	2.63
12	81	80	1.23
13	73	75	2.74
14	83	74	10.84
15	87	82	5.75
16	67	71	5.97
17	72	79	9.72
18	82	80	2.44
19	81	77	4.94
20	78	79	1.28

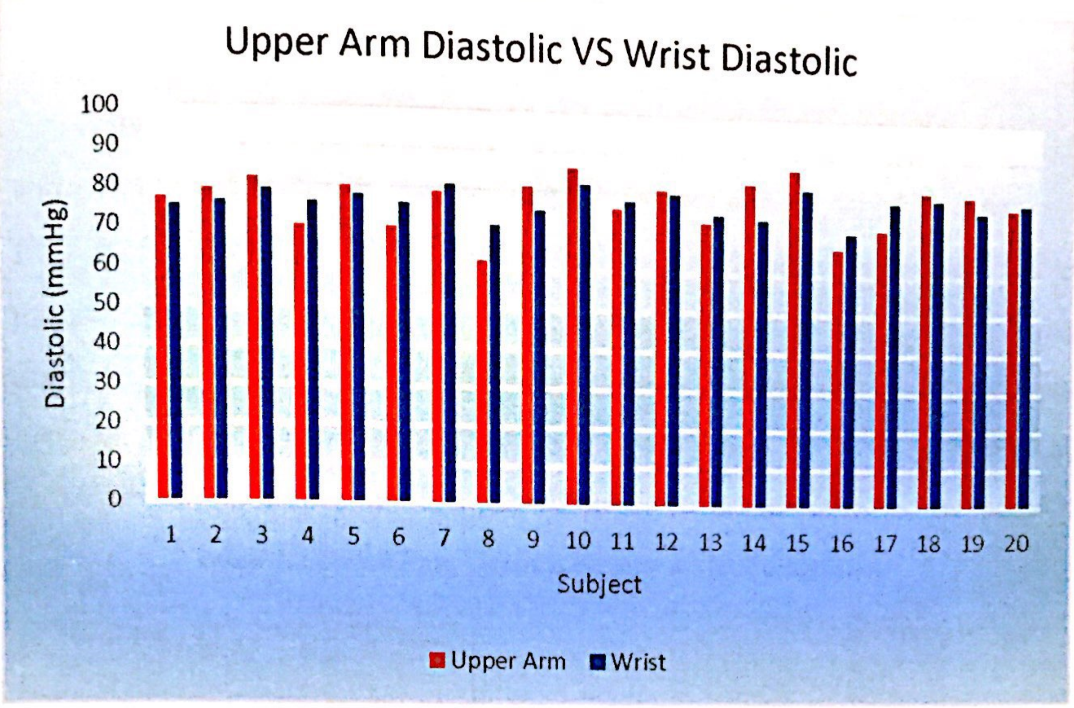


Figure 4.6 Upper arm and Wrist Blood Pressure Diastolic Comparison

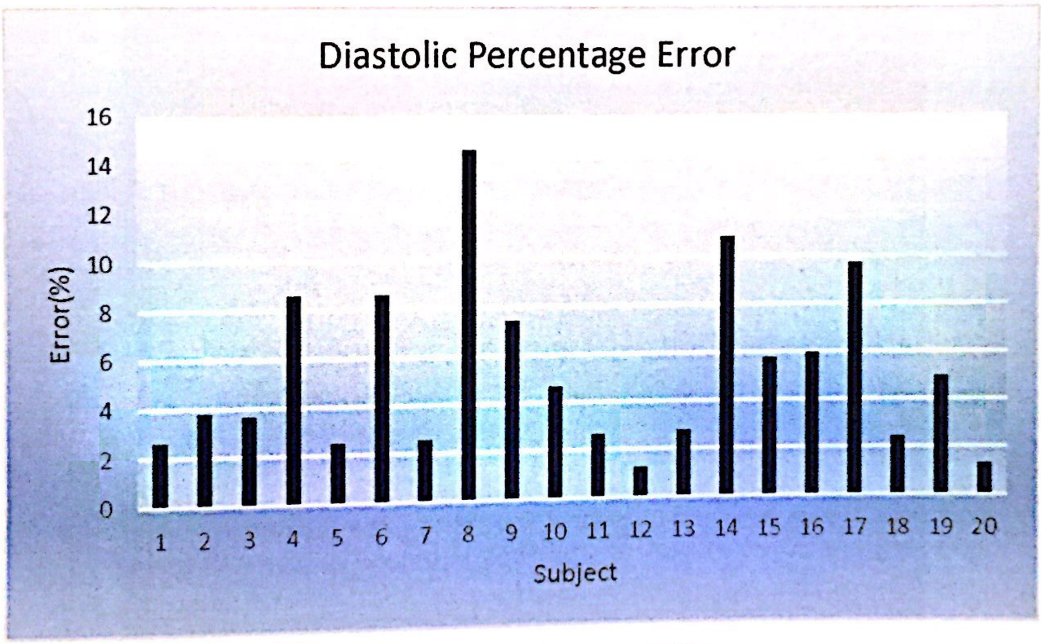


Figure 4.7 Systolic Percentage Error

4.5.3 Heart Rate

Finally, Table 4.7 below show that the comparison of heart rate upper arm and wrist blood pressure. The different between both readings is between ± 14 Beat Per Minute (Bpm). Then using the formula for percentage error, the lowest that has been calculate is 1% and the highest is 22.6%. From the table reading a graph has plotted. Figure 4.8 show the graph comparison of the systolic reading between two readings. Figure 4.9 show the percentage error for each subject.

Table 4.7 Heart Rate Upper Arm and Wrist Comparison

Subject	Upper Arm	Wrist	Percentage Error (%)
1	71	81	14.08
2	92	83	9.78
3	90	80	11.11
4	76	79	3.95
5	69	79	14.49
6	92	83	9.78
7	87	82	5.75
8	62	76	22.58
9	87	82	5.75
10	90	84	6.67
11	79	83	5.06
12	70	79	12.86
13	94	84	10.64
14	70	78	11.43
15	61	69	13.11
16	66	76	15.15
17	64	70	9.38
18	77	82	6.49
19	87	83	4.60
20	61	60	1.64

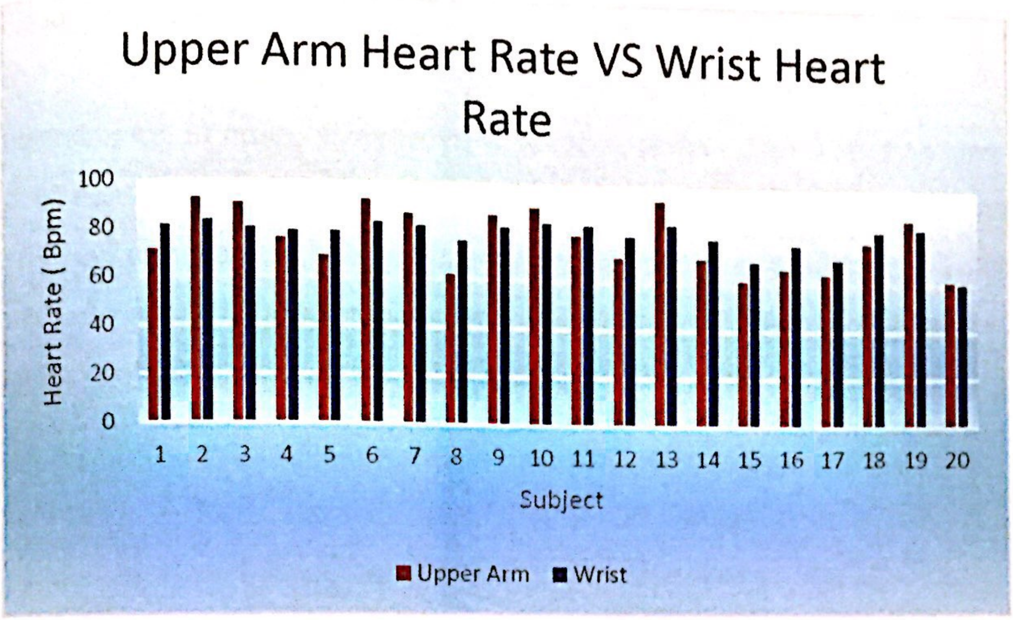


Figure 4.8 Upper arm and Wrist Blood Pressure Heart Rate Comparison

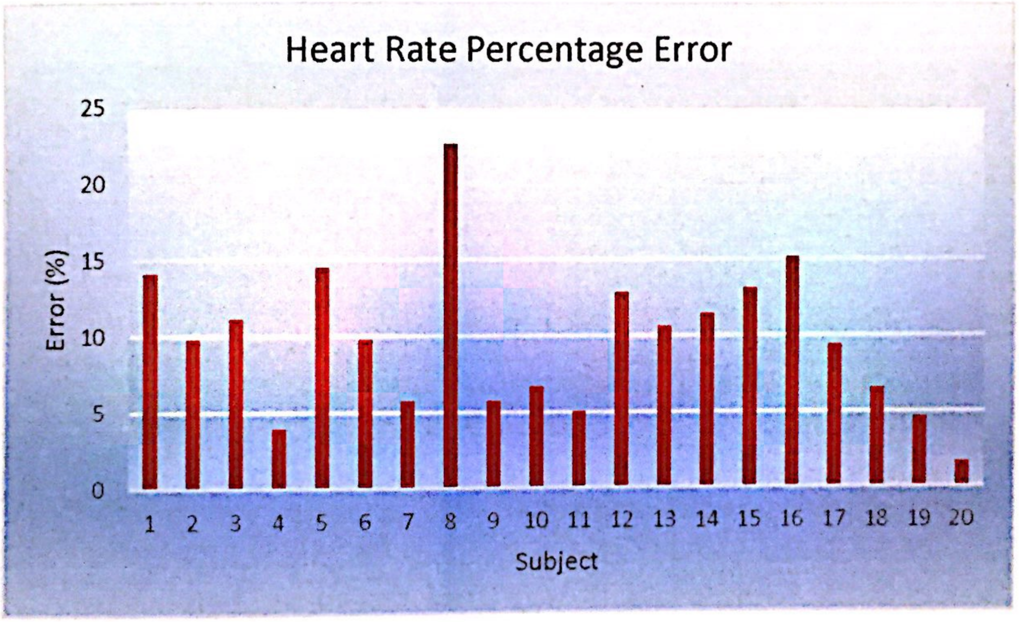


Figure 4.9 Heart Rate Percentage Error

4.6 DISCUSSION

Furthermore, in order of objective is to create a device with friendly user. This project is non –invasive device, where patient can easily monitor their reading. Moreover, the user can easily bring this device because it is a portable. Totally the different both reading is between upper arm and wrist is ± 15 mmHg and while for the heart rate is ± 14 bpm. Overall the value is acceptable.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Therefore, the conclusion of the project has successful achieved as in the objective. Which is design a wrist blood pressure that can transfer to mobile application. Which means blood pressure now can measure only form the wrist compare to normal method which is on the upper arm. Secondly, is to develop a smart phone application which can be used on android operating system. An Android smart phone application has been develop to receive the result of the blood pressure thru blood then display it on the application. It can be measure from a distance.

Finally is to compare the accuracy reading from wrist blood pressure with the upper arm blood pressure. The comparison between upper and wrist blood pressure result has been compare. Overall the different is $\pm$ 15 which means the result is acceptable. Overall of this experiment in my project and at the end of this project all the objective has been achieved successfully.

5.2 RECOMMENDATION

Recommendation of this project is to combine three parameter which is heart rate, blood pressure and spo2. It's because this parameter used the same. Secondly, Wrist monitors have potential but need to be test more. As long as the wrist is always at heart level when the readings are taken. Next is it can record continuous reading. Then, upgrade the sensor to get accuracy cause existing sensor is not stabile.Finally, a suitable design for the for the casing & the placement of the cuff.

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```
#define start_sw PORTE.F0

#define sw1 PORTC.F0

#define sw2 PORTC.F1

#define sw3 PORTC.F2

#define valve PORTD.F0

#define pump  PORTD.F1

#define start_flag flag.F0

#define error_flag flag.F1

#define error1 flag.F2


#define TX PORTC,0

#define packet_len 2


char    ncnt absolute 0x20;

char    bt absolute 0x21;

char    sum absolute 0x22;

char    mtx_buffer absolute 0x23;

char    mtx_buffer1 absolute 0x24;

char    mtx_delay absolute 0x25;

char    count1 absolute 0x26;

char    count2 absolute 0x27;

char    counta absolute 0x28;

char    countb absolute 0x29;
```

```
char txt[12];
char sys[3];
char pulse[3];
char dia[3];
char flag;
double mmHg;
char counter;
int temp;
int systolic_val ;
int diastolic_val;
int pulse_rate;
char msec,sec,minutes;
char WriteCounter = 0;
char TempRead = 0;
char TempWrite = 0;


void beep(void);
void delay1s(void);
void beep(void);
void start_pump(void);
void detect_systolic(void);
void detect_diastolic(void);
void detect_pulse_rate(void);
void display_result(void);
void transmit_data(void);
```

```
void fake_systolic(void);

void fake_diastolic(void);

void fake_pulse(void);

void display_error(void);

void check_output(void);

void save_result(void);

void recall_result(void);


void display_start(void)

{

 Lcd_Out(1,1, "Blood Preassure");

 Lcd_Out(2,1, " Monitor Sys");

}

void interrupt(){


 if (INTCON.T0IF){

    asm{clrwdt}

    msec++;

    if (msec >253){

      msec = 0;

      sec++;

        if (sec >=60){

          sec = 0;

          minutes++;

        }
```

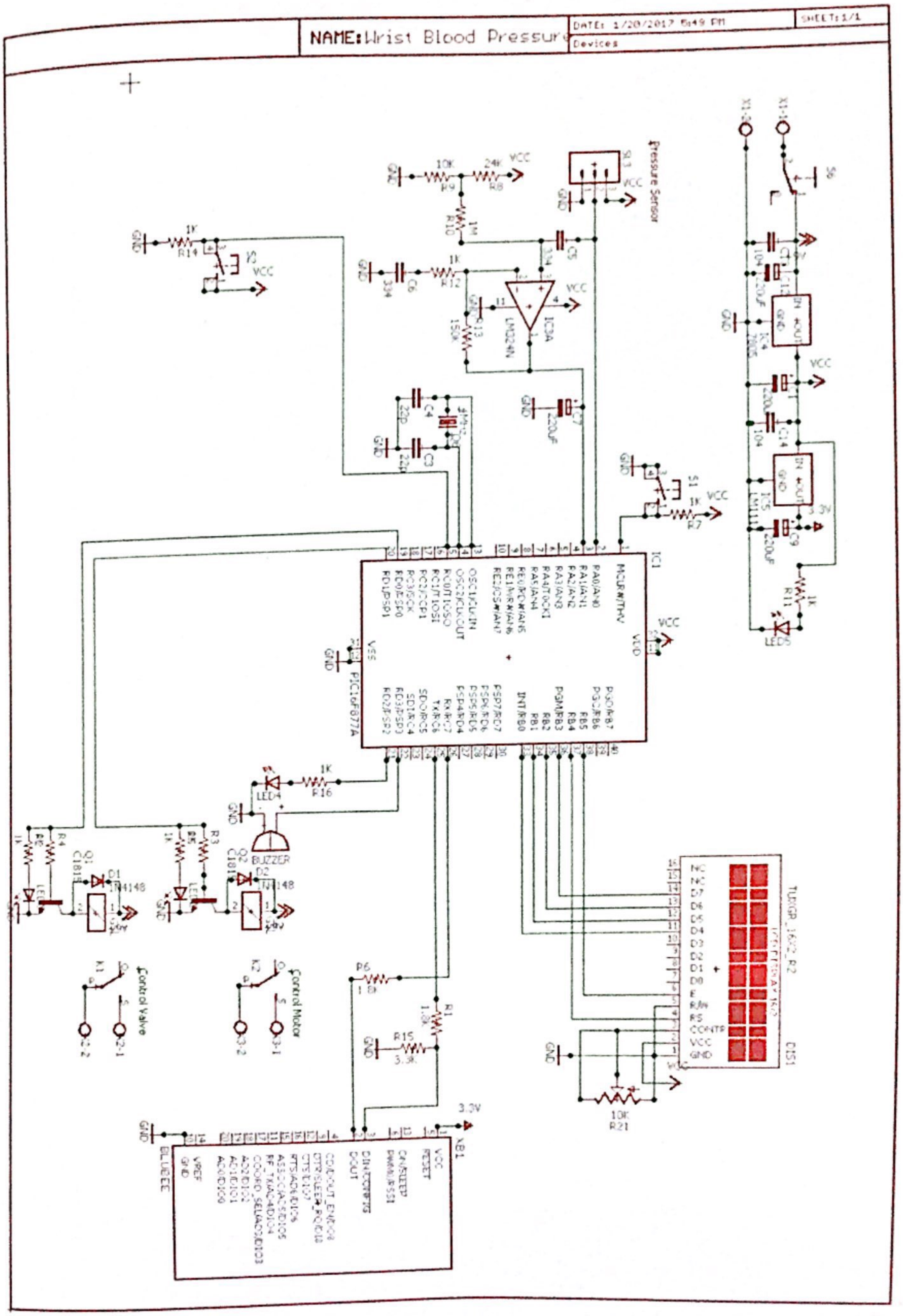
```
    }
  }
  TMR0  = 4;
  INTCON = 0x20;       // Set T0IE, clear T0IF
}
void main()
{
  ADCON1 = 0x82;             // Configure analog inputs and Vref
  TRISA  = 0xFF;             // PORTA is input
  TRISB  = 0b00000000;             //
  TRISC  = 0b11111111;
  TRISD  = 0b00000000;
  TRISE  = 0x01;
  OPTION_REG = 0x03;       // Assign prescaler to TMR0
  INTCON = 0xA0;       // Enable TMRO interrupt
  PORTB=PORTC=PORTD=PORTE  = 0x00;
  Delay_ms(50);
  LCD_Config(&PORTB,4,5,6,3,2,1,0);
  Lcd_Init(&PORTB);                   // Lcd_Init_EP4, see
Autocomplete
  LCD_Cmd(LCD_CURSOR_OFF);               // send command to
LCD (cursor off)
  LCD_Cmd(LCD_CLEAR);                    // send command  to LCD
(clear LCD)
```

```
display_start();
 Delay_ms(2000);
 LCD_Cmd(LCD_CLEAR);
 Usart_init(9600);
 start_flag=0;

ncnt=bt=sum=mtx_buffer=mtx_buffer1=mtx_delay=count1=count2=c
ounta=countb=0;
 systolic_val=diastolic_val=pulse_rate=0;
 sec=0;
 if(eeprom_read(0xFF) >= 10)
 {
  delay_ms(100);
  eeprom_write(0xFF,0x00);
 }
 TempRead = 0;
do
{
 Lcd_Out(1,1, "Press Function");
// ByteToStr(sec,txt);
// Lcd_chr(2,1,txt[0]);
// Lcd_chr_cp(txt[1]);
// Lcd_chr_cp(txt[2]);
//  if(sec==30){
 if(sw1)
```

```
{
  LCD_Cmd(LCD_CLEAR);
 mmHg = ADC_Read(0);
 mmHg = ((mmHg * 5)/1023)* 75 ;
//  if(mmHg>=35)goto error;
  start_flag=1;
  beep();
  start_pump();
  fake_systolic();
  fake_diastolic();
  fake_pulse();
//   detect_systolic();
//   beep();
//   detect_pulse_rate();
//   detect_diastolic();
   valve = 1;
   delay_ms(1);
   if(!error_flag){
   display_result();
   save_result();
   Delay_ms(10000);
   LCD_Cmd(LCD_CLEAR);    }
   else
 error:
   display_error();le(1);
```

APPENDICE B:- SCHEMATIC DIAGRAM



APPENDICE C:- PCB LAYOUT