DEVELOPMENT OF ARM MOVEMENT NOTIFICATION SYSTEM

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power Systems)"

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power Systems)

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Signature : ________________________________

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Date : 27 NOVEMBER 2007

Specially dedicated to my beloved
mother, father and family

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In the name of Allah, The Most Loving and The Most Compassionate

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ABSTRACT

Cybernetics is a study of communication and control concept related to living organisms with machines. The essential goal of cybernetics is to understand and define the functions and processes of systems (biology). In this project, it will be focus on creating significant signals for respective biology motions of human arm. The application in the future will be the real time adaptation movement of biology human arm towards a mechanical arm. To achieve this goal, an arm movement notification system is developed. This system consists of 2 parts. Firstly the mechanical arm-glove where it will be the sensor that will produce the significant signals for each specific movements made by the human arm. Secondly, a microcontroller system where the significant signal inputs from the arm-glove will be process, identify and show the types of movement on the LCD display which is the degrees position of the human-arm.

ABSTRAK

Sibernatik adalah ilmu kajian yang tertumpu kepada sistem kawalan dan komunikasi (perhubungan) antara hidupan seperti manusia dan haiwan dengan jentera mekanikal. Matlamat utama sibernatik adalah untuk memahami dan menterjemahkan fungsi dan proses sesuatu sistem biologi. Dalam projek ini, tumpuan akan diberikan dalam mencipta isyarat-isyarat yang signifikan yang dapat dihasilkan oleh lengan manusia. Aplikasi teknologi ini kelak akan diguna pakai dalam mengawal lengan mekanikal dengan menggunakan pergerakan biologi lengan manusia itu sendiri dalam keadaan masa langsung. Untuk mencapai matlamat ini, sistem notifikasi pergerakan lengan manusia dicipta. Sistem ini terdiri daripada 2 bahagian. Pertama sarung-lengan mekanikal dimana ia akan menempatkan alat-alat pengesan untuk megeluarkan isyarat-isyarat yang signifikan apabila lengan manusia melakukan pergerakkan yang tertentu. Kedua, system kawalan mikro yang akan memproses signal-signal tersebut daripada sarung-lengan mekanikal untuk diproses, diterjemah dan dipaparkan jenis pergerakkan yang dilakukan pada skrin paparan LCD iaitu dengan menunjukkan posisi lengan manusia tersebut dalam bacaan sudut darjah.

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LIST OF ABBREVIATIONS

LCD	-	Liquid-Crystal Displays
OSC	-	Oscillator
MSB	-	Most Significant Bit
LSB	-	Least Significant Bit
ADC	-	Analog to Digital Converter
A/D	-	Analog to Digital
REFF	-	Reference
MAX	-	Maximum
GND	-	Ground
PIC	-	Peripheral Interface Controller
I/O	-	Input/Output
RAM	-	Random Access Memory
SS	-	Sampling Switch
VA	-	Voltage Source

LIST OF SYMBOLS

μ	-	Micro
k	-	Kilo
kHz	-	Kilo Hertz
V	-	Volts
DC	-	Direct Current
cm	-	Centimeter
n	-	Number of bit
η	-	Nano
m	-	Mili

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CHAPTER 1

INTRODUCTION

1.1 Background

According to Macmillan English Dictionary for Advance Learners International Student Edition (2006), the term cybernetics meaning “the use of technology to make copies of natural things, for example artificial body parts”. The original term *cybernetics* stems from the Greek Κυβερνήτης (*kybernetes*, steersman, governor, pilot, or rudder — the same root as government) [7]. It is a study of communication and control concept related to living organisms with machines. Its focus is how anything (digital, mechanical or biological) processes information, reacts to information, and changes or can be changed to better accomplish the first two tasks [8]. A more philosophical definition, suggested in 1956 by Louis Couffignal, one of the pioneers of cybernetics, characterizes cybernetics as "the art of ensuring the efficacy of action”[9]. The most recent definition has been proposed by Louis Kauffman, President of the American Society for Cybernetics, "Cybernetics is the study of systems and processes that interact with themselves and produce themselves from themselves”[7].

Cybernetics is a broad field of study, but the essential goal of cybernetics is to understand and define the functions and processes of systems (biology) [7]. In this project it will be focus on creating significant signals for respective biology motions of human arm. The application in the future will be the real time adaptation movement of biology human arm towards a mechanical arm. To achieve this goal, an arm movement notification system is developed. This system consists of 2 parts. Firstly the mechanical arm-glove where it will be the sensor that will produce the significant signals for each specific movements made by the human arm. Secondly, a microcontroller system where the significant signal inputs from the arm-glove will be process, identify and show the types of movement on the LCD display which is the degrees position of the human-arm.

1.2 Project Objective

The objectives of this project are fabricating suitable arm-glove that attach with sensors that can detect the specific movements of human arm and to develop an arm movement notification system.

1.3 Project Scope

In this project, there are 2 scopes that have been taken into research and experiments. They are fabrication of mechanical arm-glove with sensors and data acquisition unit for movement notification.

CHAPTER 2

LITERATURE REVIEW

2.1 Anatomy of Human Arm Movement

Anatomically, the term arm refers specifically to the segment between shoulder and elbow [1]. The segment between elbow and wrist is forearm [1]. However, the term arm usually refers to the point from shoulder to wrist connected by elbow. In this project, the term of upper-arm refers to the segment between the elbow and wrist. Meanwhile lower-arm will be refers to the segment between shoulder and elbow. Arms are one of the important parts of human body. It is used to do multiple and manipulative tasks such as climbing, driving a steering and so on.

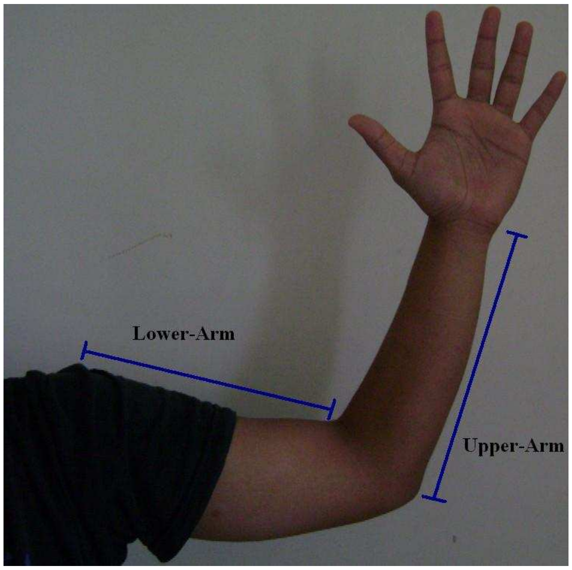

Figure 2.1 Parts of human arm

The ball and socket shoulder joint allows for movement of the arms in a wide circular plane, while the presence of two forearm bones which can rotate around each other allows for additional range of motion at this level [1]. The axis of movement of arm can be divided into 2 which are X-Y axis and Y-Z axis. The range of degrees for both axis are from 0 degrees to 90 degrees.

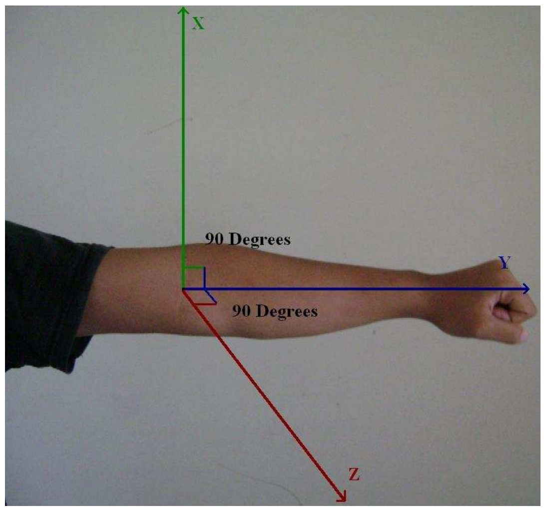

Figure 2.2 Axis of movements for human arm

2.2 Potentiometer

Potentiometer is a type of resistor that can varible its resistances in a certain ranges. A potentiometer was an instrument to measure the potential (or voltage) in a circuit by tapping off a fraction of a known voltage from a resistive slide wire and comparing it with the unknown voltage by means of a galvanometer [2].

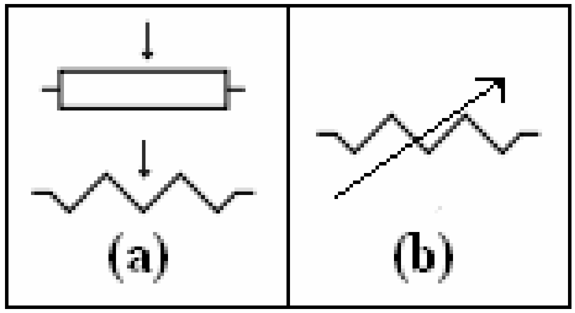

Figure 2.3 Potentiometer schematic symbols

The word of potentiometer derives from the phrase "voltage potential," and "potential" was used to refer to "strength". Usually, potentiometer has three terminal where the sliding contact in the center (the wiper). It will act as a variable voltage divider if all three terminals are used and acts as a varible resistor if only two terminals are used. The original potentiometer is a type of bridge circuit for measuring voltages by comparison between a small fraction of the voltage which could be precisely measured, then balancing the two circuits to get null current flow which could be precisely measured [2].

Figure 2.4 Typical 3-Terminals Potentiometer

Implementation of potentiometers are rarely used to control anything the applied resistive losses and adding concept such as light dimmer and volume controls on audio equipment by varible the input voltage analog signal. Potentiometers used to control high power are normally called rheostats [2].

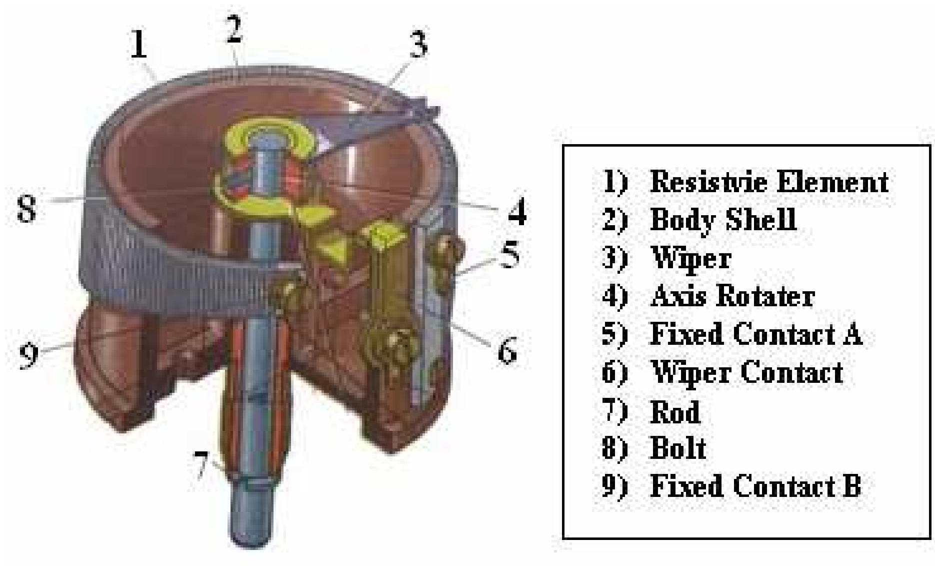

Figure 2.5 Parts of Potentiometer

Figure 2.5 above show the basic construction parts of a potentiometer. The main body construction is the body shell as the casing and rod for rotating mechanism. The resistive element will be in a anulus design. Its element could be flat graphite, wire/carbon particles in plastic and ceramic/metal mixture called cermet. The resistive element contacted with a wiper contact slide around this annulus. The wiper being hold and rotate by axis rotater. The wiper being fixed connected to the wiper contact. As the wiper slide around the resistvie element, it will create resistive potential either at fixed contact A or fixed contact B.

2.3 Analog to Digital Converter Concept

An analog-to-digital converter (abbreviated ADC, A/D or A to D) is an electronic integrated circuit, which converts continuous signals to discrete digital numbers [3]. ADC converts an input analog voltage or current to a digital number by using different coding schemes such as binary, Gray code or two's complement binary. In ADC, there are two important terms that should be understand which are resolution and bit of the converter. Resolution indicates the number of quantization codes that it can produce over a minimum increment of the analog input values.

$$\text{Max Quantization Code} = 2^{(n-1)} \qquad \text{....Eq 1}$$

The range of the quantization code being determine by the bits used by the ADC;

$$\text{Re}\,solution = \frac{+V_{REF}}{\text{Max Quantization Code}} \qquad \text{....Eq 2}$$

For example, a 10-bit ADC where its $+V_{REF}$ = 5V and $-V_{REF}$ = 0V could produce range from 0 to 1023 of discrete values and its voltage resolution are 1 quantization code for every increment of 4.88mV.

The analog signal is continuous in time and it is necessary to convert this to a flow of digital values according to the input time. Thus, a conversion time required to define the rate at which new digital values are sampled from the analog signal. The rate of converting new quantization values is called the sampling rate or sampling frequency of the converter.

Since a practical ADC cannot make an instantaneous conversion, the input value must necessarily be held constant during the time that the converter performs a conversion (called the conversion time) [3]. A circuit called a sample and hold performs this operation by using a capacitor to store the analog voltage at the input and use an electronic switch to disconnect the capacitor from the input. Nowadays, most ADC integrated circuits include internal sample and hold subsystem.

2.4 PIC16F873 Features

PIC16F873 is a group of PIC series from Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division [6]. The acronym for PIC is “Programmable Intelligent Computer” or “Peripheral Interface Controller”. PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming plus re-programming with flash memory capability [6].

PIC16F873 has 3 ports which are port A, port B and port C. Port A has 5 I/O channel and capable to receive digital and analog input signal. Meanwhile for Port B and Port C have 7 I/O digital channel. Its also has build-in features such as FLASH Program Memory, Data Memory (RAM), EEPROM Data Memory and 10-bit multi-channel analog to digital converter (ADC) system. There are 3 languages could be use to program the PIC16F873 which\ are C programming, assembly and PICBasic code. PICBasic programming will be used since its command codes are easier and simple to implement compare to the rest.

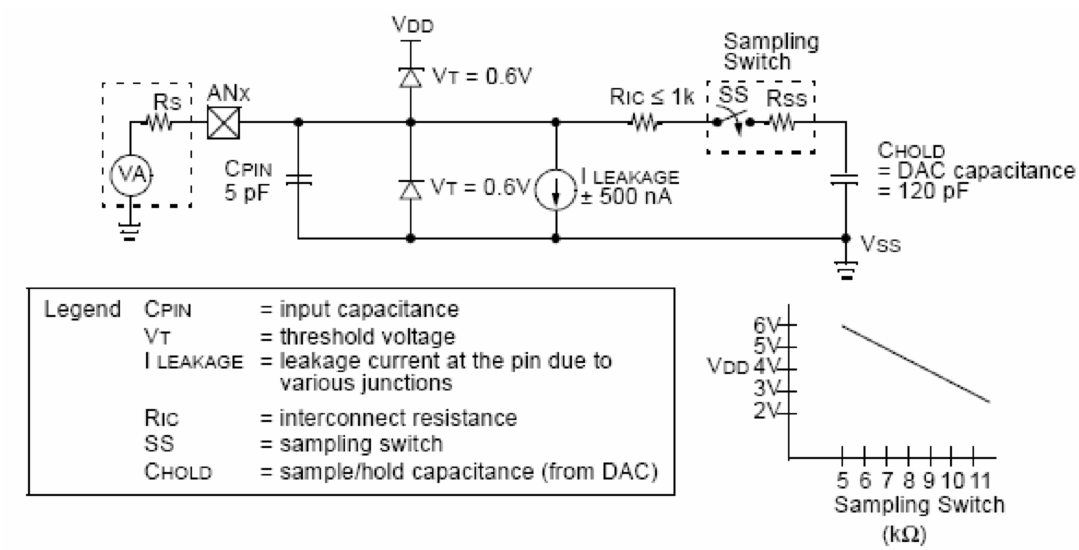

Figure 2.6 PIC16F873 ADC Analog Input Model [4]

In PIC16F973 ADC module, the internal ADC circuit as shown in Figure 2.7. The analog input voltage from voltage source (VA) will be variable by potentiometer-R_S (source impedance). The varied voltage then will charge a sample and hold capacitor (C_{HOLD}). The source impedance (R_S) and the internal sampling switch (R_{SS}) impedance directly affect the time required to charge the capacitor

C_{HOLD} [4]. The device voltage (V_{DD}) varies the impedance of the sampling switch (R_{SS}) as in figure 1.7. The output of the sample then is the input to the converter. The converter will generate a digital result of this analog level via successive approximation [4]. The conversion will result in 10-bit digital number for PIC16F873. 10kΩ is the maximum recommended impedance for analog sources (R_S) because it meets with need of the pin leakage specification. The acquisition time may be decreased as the impedance decreased.

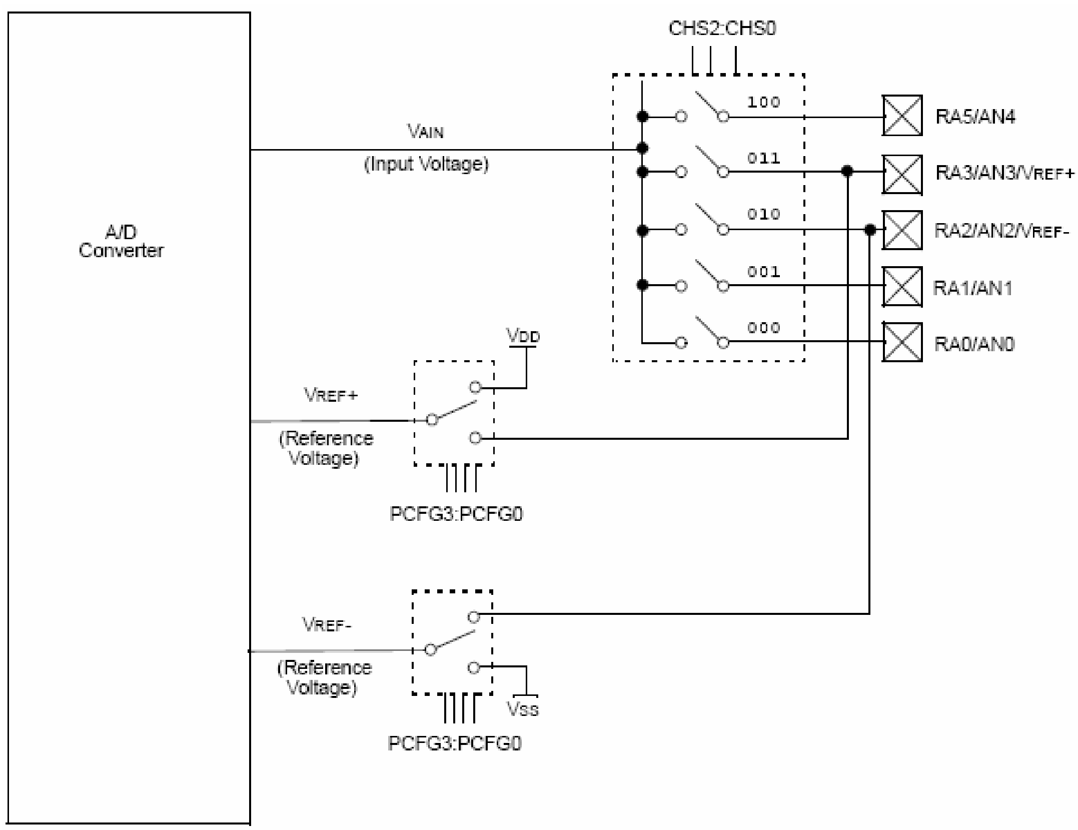

Figure 2.7 PIC16F873 ADC Block Diagram [4]

The A/D conversion time per bit is defined as T_{AD} where the source is software selected. There are 4 possible options for T_{AD} which are $2T_{OSC}$, $8T_{OSC}$, $32T_{OSC}$ and internal A/D module RC oscillator (2-6 microseconds). T_{AD} is the time for the holding capacitor (C_{HOLD}) to be fully charge thus gives the input of voltage level to the converter. Any A/D conversion clock selected must ensure that T_{AD} minimum time is 1.6 microseconds.

Table 2.1 T_{AD} vs. Maximum Device Operating Frequencies [4]

AD Clock Source (TAD)		Maximum Device Frequency
Operation	ADCS1:ADCS0	Max.
2Tosc	00	1.25 MHz
8Tosc	01	5 MHz
32Tosc	10	20 MHz
RC(1, 2, 3)	11	**(Note 1)**

Note 1: The RC source has a typical TAD time of 4 µs, but can vary between 2-6 µs.
2: When the device frequencies are greater than 1 MHz, the RC A/D conversion clock source is only recommended for SLEEP operation.

Meanwhile $2T_{AD}$ is the minimum wait time requires before the next acquisition starts. Figure 1.9 below illustrates the equation to calculate the minimum acquisition time. ½ LSb error (1024 steps for the A/D) being assume used in the equation where it is the maximum error allowed for the A/D to meet its specified resolution. Since the charge holding capacitor (C_{HOLD}) is not discharged after each conversion, it is vital to set the $2T_{AD}$ delay before the next A/D conversion repeat. During the $2T_{AD}$ delay, disconnect the connection between the holding capacitor and the selected A/D input channel.

$$\begin{aligned} T_{ACQ} &= T_{AMP} + T_C + T_{COFF} \\ &= 2\mu s + T_C + [(\text{Temperature} - 25°C)(0.05\mu s/°C)] \end{aligned}$$

$$\begin{aligned} T_C &= C_{HOLD}(R_{IC} + R_{SS} + R_S)\ln(1/2047) \\ &= -120pF\,(1k\Omega + 7k\Omega + 10k\Omega)\ln(0.0004885) \\ &= 16.47\mu s \end{aligned} \quad \text{…Eq 3}$$

$$\begin{aligned} \therefore T_{ACQ} &= 2\mu s + 16.47\mu s + [(50°C - 25°C)(0.05\mu s/°C) \\ &= 19.72\mu s \end{aligned}$$

$$\begin{aligned} T_{ACQ} &= \text{Acquisition Time} \\ T_{AMP} &= \text{Amplifier Settling Time} \\ T_C &= \text{Hold Capacitor Charging Time} \\ T_{COFF} &= \text{Temperature Coefficient} \end{aligned}$$

For ADC PIC16F873 programming ADC module, there are 4 important register which are;

i. ADRESH: For high register
ii. ADRESL: For low register
iii. ADCON0: Controls the operation of the ADC.
iv. ADCON1: Configures the function of the port pins.

The ADRESH:ADRESL register made 10-bit conversion possible. It is a pair of register where the 10-bit A/D (analog-to-digital) is loaded at the completion of the A/D conversion. The wide of the register pair is 16-bits wide thus it gives A/D module the flexibility to set either left or right justify. Figure 1.9 below illustrates the operation of the A/D result justification. The extra bits are loaded with '0's [4]. When an A/D result will not overwrite these locations (A/D disable), these registers may be used as two general purpose 8-bit registers [4].

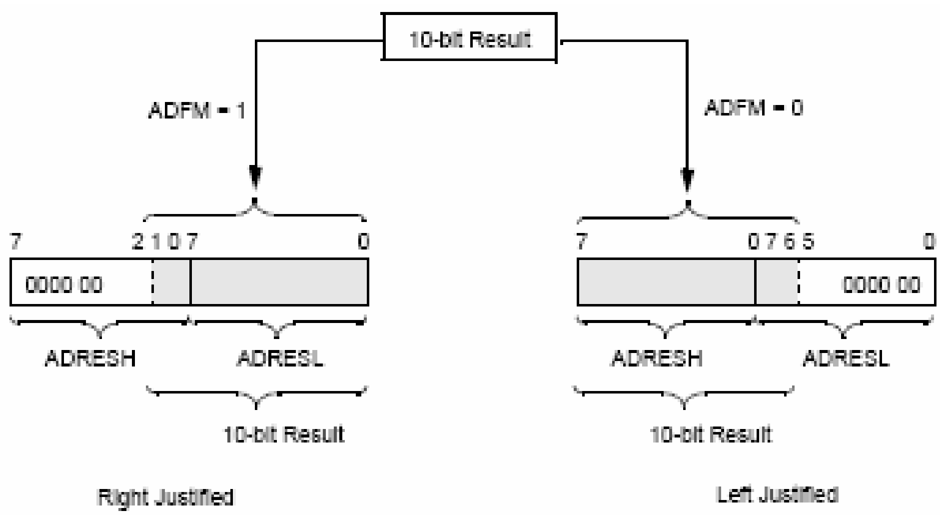

Figure 2.8 A/D Result Justifications [4]

These are the procedures of PBasic program for PIC16F873 to conduct A/D operation after setting the TRIS function (1=input & 0=output). Firstly configure the ADCON1 and ADCON0 specification as desire. Secondly configure the A/D interrupt (optional). Third is adding pause time to the program for the system required the acquisition time. Fourth is start the conversion by setting "ADCON0.2

= 1”. Fifth is wait for A/D conversion to complete with methods either waiting for the A/D interrupt or setting the GO/DONE bit to be cleared with enabled the interrupts function. Sixth is set the result of the A/D in register pair which is “ADRESH:ADRESL” (clear bit ADIF if required). Lastly go to step 1 or step 2 for the next conversion as required.

CHAPTER 3

SYSTEM DESIGN

3.1 Overall System Design & Operation

This chapter explains about the development of arm movement notification system project architectures adapted from the relevant information gathered through literature review. The designs divided into 3 categories which are construction method for mechanical arm-glove, electronic circuit for movement detection design and PBasic programming structure. Before go on with the details, it is best to begin with brief review of the correlation of all methods as in Figure 3.1 and Figure 3.2.

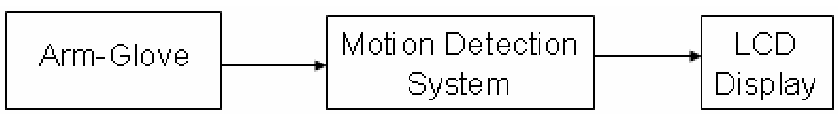

Figure 3.3 Block Diagram of Overall System

The arm-glove will be attached to human arm. The glove will be install with sensors which is the potentiometer to detect the arm movement in X-Y axis and Y-Z axis. The design of the glove must provide 2 angles of freedom towards the arm. The analog voltage signals from the arm-glove will be transmit to the motion detection system where PIC16F873 will be use as the microcontroller system. The PIC16F873 will convert the analog voltage signals into a range of respective digital numbers by using ADC method. The illustration of the digital numbers will appear on the LCD display. The digital numbers then will be analyzing to determine the suitable digital numbers with the degrees of the human arm movements. Result form the analysis results will be set into the PBasic programming therefore the LCD display will automatically display the degrees position towards the respective movement of the human arm.

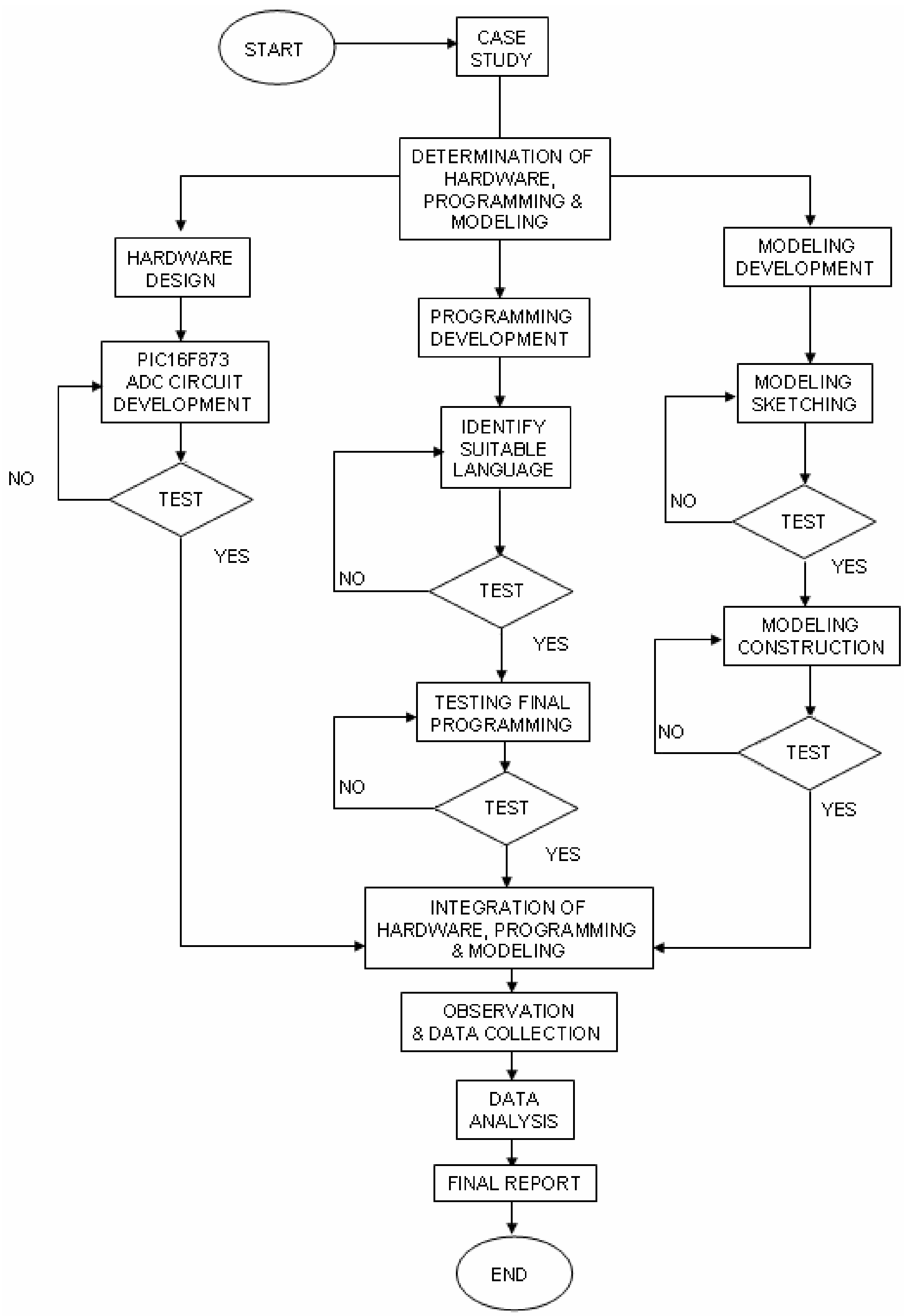

Figure 3.4 Complete Project's Methodology Flow

3.2 Mechanical Arm-Glove Design

The arm-glove will be the device where it will adapt the movement of human arm. There are 2 points need to be taken into consideration during design and constructing the arm-glove. First, the arm-glove must provide 2 angle of freedom towards the human arm motion without disturbing its natural movement characteristics. Second, the position of the sensors (potentiometers) that will be place to detect the human arm motion efficiently.

Figure 3.5 Wearing Arm-Glove X-Y Position

Figure 3.6 Wearing Arm-Glove Y-Z Position

3.2.1 X-Y Axis Arm Movement Mechanism

Figure 3.5 below show the full design for X-Y axis segment. This segment consists of XY-Holder, XY1-Connector, XY2-Connector and XY-Ring-Slider. The XY-Holder will be place at the upper-arm and XY-Ring-Slider will be place at the lower-arm. The XY-Holder and XY-Ring-Slide will be connected by XY1-Connector and XY2-Connector. Therefore, the angle of freedom for the X-Y axis segment has been created.

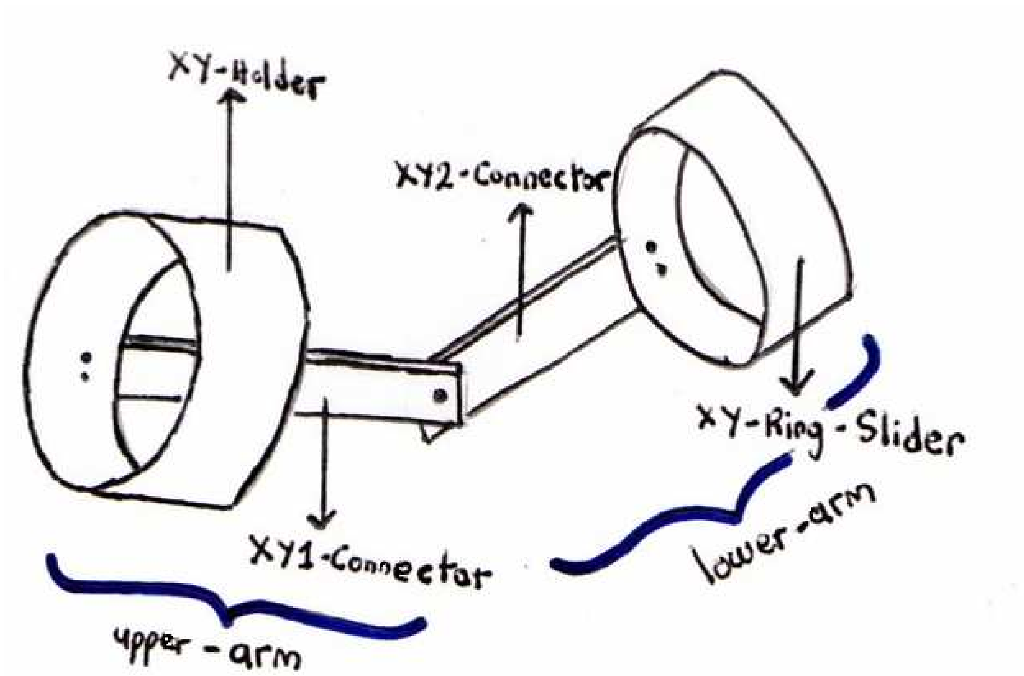

Figure 3.7 Design for X-Y Axis Segment

The position of the potentiometer 1 (sensor 1) can be determine by analysis and locate the point-of-rotating as in Figure 3.6. It is a point where when human arm make movements, it will create spiral motion. For X-Y axis, the point-of-rotating will be at the joint between XY1-Connector and XY2-Connector. Thus, the potentiometer 1 (sensor 1) can be place at the point-of-rotating to senses the X-Y movement of the human arm where XY-Holder (Upper-Arm) will be the vector and XY-Ring-Slide (lower-arm) will be the static.

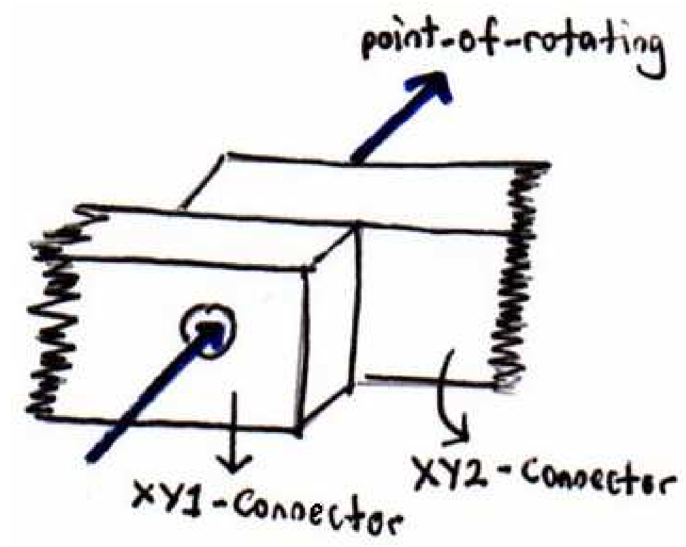

Figure 3.8 Position of Potentiometer 1 (Sensor 1) of X-Y Axis

Figure 3.7 illustrate the exact picture for X-Y axis segment of the arm-glove. Picture A in the figure 3.6 show the position 0 degrees of the arm meanwhile in picture B shows the position 90 degrees of the arm. Picture C shows the placement of the sensor 1 (potentiometer 1) at the point-of-rotating.

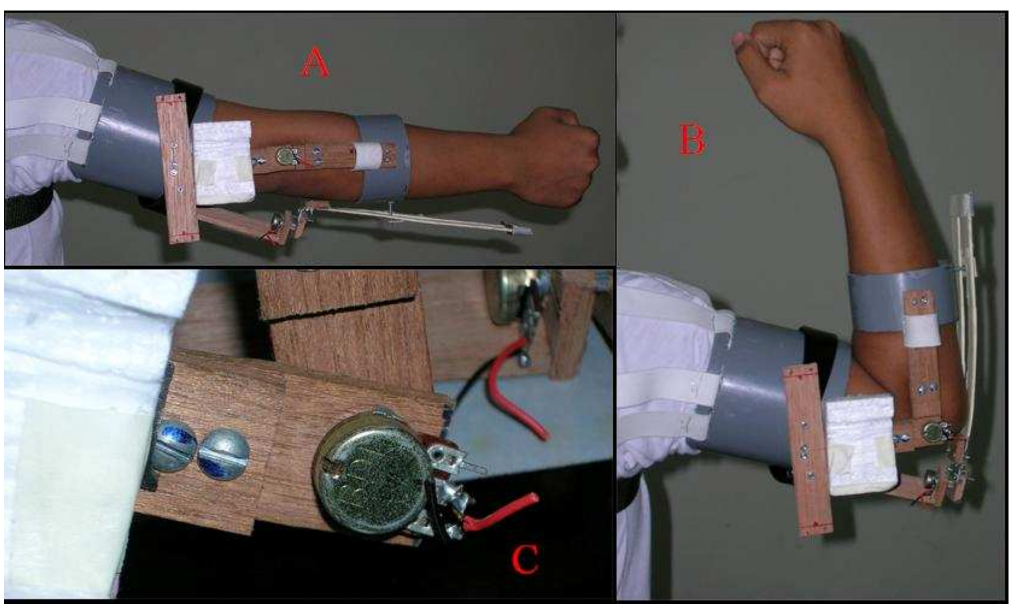

Figure 3.9 Exact Picture for X-Y Axis Segment

3.2.2 Y-Z Axis Arm Movement Mechanism

Figure 3.8 below show the full design for Y-Z axis segment. This segment consists of YZ-Holder, YZ-Connector, YZ-Freedom and YZ-Rail-Slide. For Y-Z axis movement, the YZ-Holder will use on human chest in order to be act as the static. This is done because it is the most suitable technique to create angle-of-freedom for the Y-Z axis movement mechanism. The YZ-Holder will be joining with the YZ-Rail-Slide and YZ-Freedom by the YZ-Connector. YZ-Freedom and YZ-Rail-Slide as being detail view in Figure 3.9 are specially design to meet the fulfill angle-of-freedom requirement for Y-Z axis movements mechanism. From the joining parts, the angle-of-freedom for the Y-Z axis segment has been created.

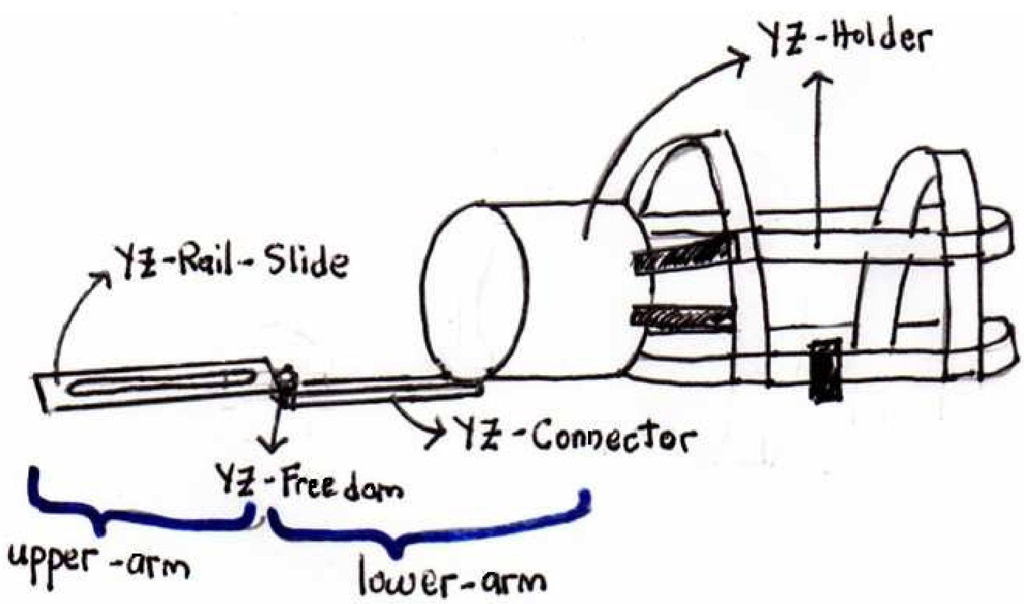

Figure 3.10 Design for Y-Z Axis Segment

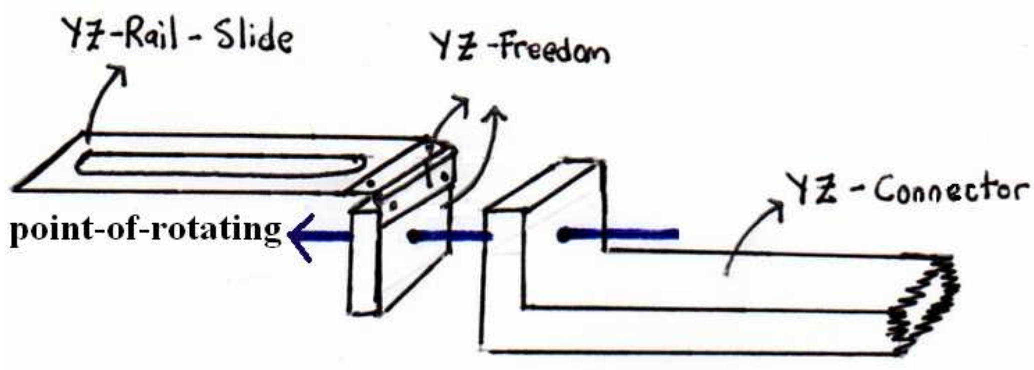

Figure 3.11 Detail View for YZ-Freedom, YZ-Rail-Slide & YZ-Connector

Figure 3.10 illustrate the exact picture for Y-Z axis segment of the arm-glove. Picture A in the figure 310 show the position 0 degrees of the arm meanwhile in picture B shows the position 90 degrees of the arm. Picture C shows the placement of the sensor 2 (potentiometer 2) at the point-of-rotating.

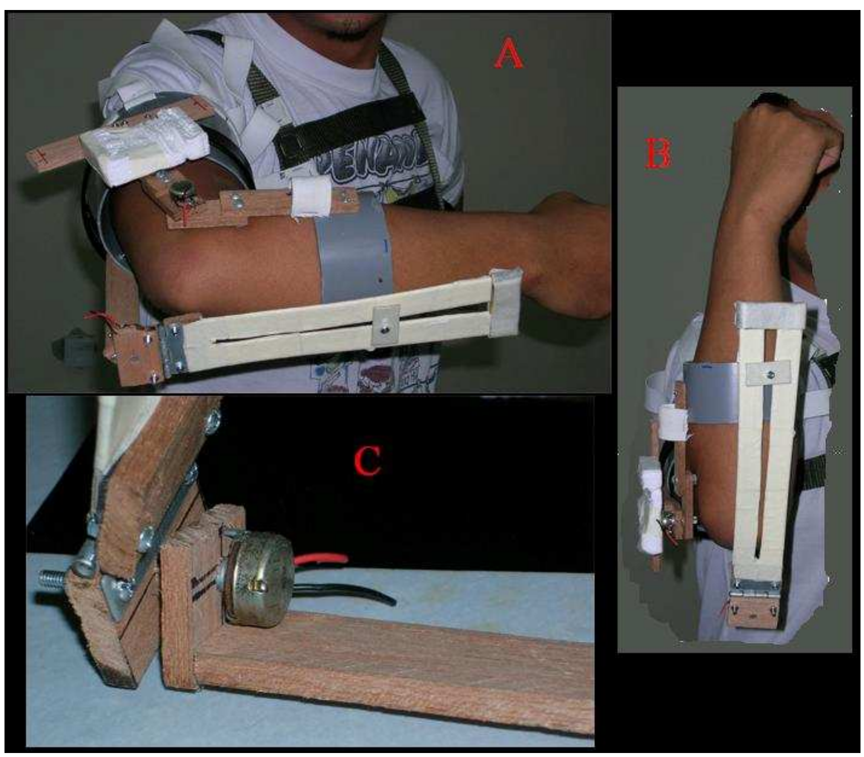

Figure 3.12 Exact Picture for Y-Z Axis Segment

3.3 Electronic Circuit For Movement Notification

This section explains about the electronic system that designed to notify the human arm movement in digital form. The block diagram of the detection and identifies process electronic circuit system is shown in Figure 3.11 below.

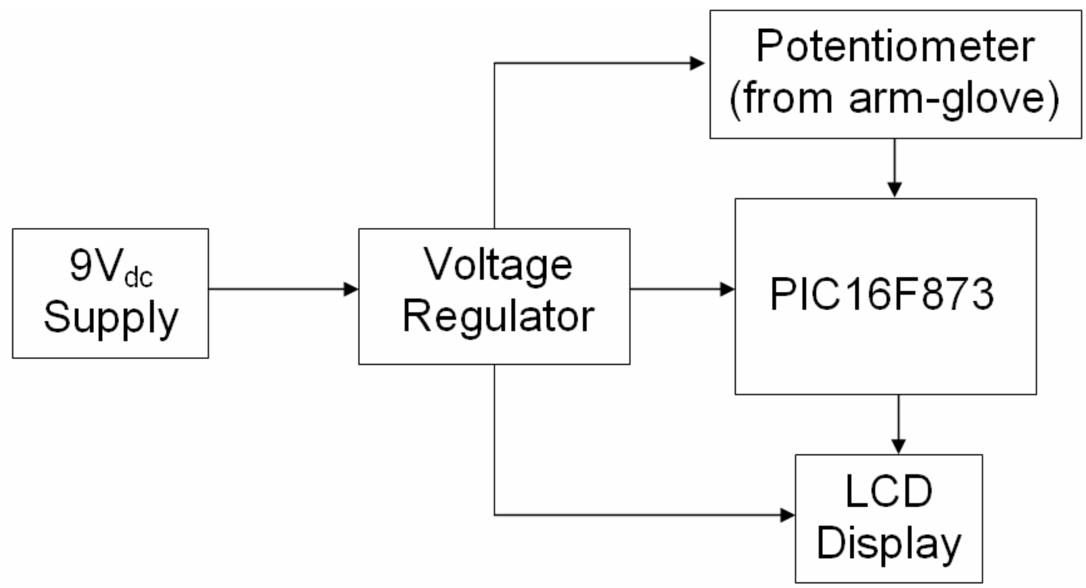

Figure 3.13 Block Diagram of Electronic Circuit System

$9V_{DC}$ battery will be the main voltage source for the electronic circuit system. The voltage regulator which is the LM7805 will regulate the $9V_{DC}$ supply into constant $5V_{DC}$ which is the suitable maximum voltage for PIC16F873 and LCD display to operate efficiently. The $5V_{DC}$ will supplied to the potentiometers, PIC16F873 and LCD display.

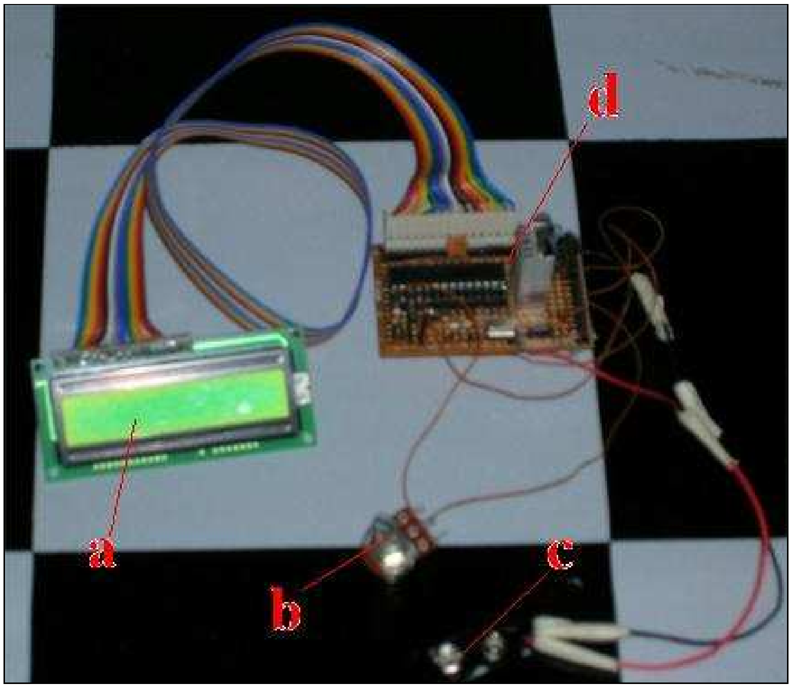

Figure 3.14 Electronic Circuit System

Figure 3.12 illustrate the exact picture of the electronic circuit system of the arm motion detection. Label-a is the LCD display where the data's processed being display. Label-d is the main circuit which consists of PIC16F873 and voltage regulator LM7805. Label-b is the testing potentiometer and label-c is the $9V_{DC}$ battery cap.

3.3.1 Processing Unit on Notification System

PIC 16F873 is used in order to detect the changes of input analog voltage from the potentiometer and convert it into digital (analog to digital conversion process) thus display the data's on the LCD display. PIC 16F873 has 3 ports which are port A, port B and port C. Port A will be the analog voltage input signal where channel A-0 will be connected to potentiometer-1 and channel A-1 will be connected to potentiometer-2. $+V_{REF}$ will connect to channel A-2 and $-V_{REF}$ to channel A-3. Meanwhile, Port B and Port C will be the output that will transmit processed signal to the LCD display. The oscillator of 12MHz will use on the PIC16F873.

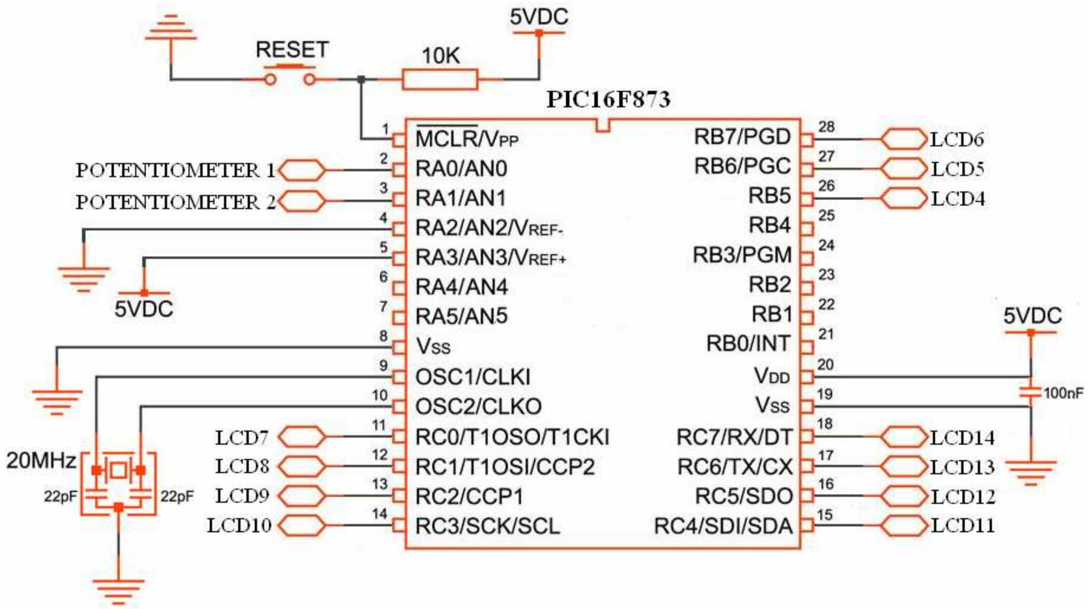

Figure 3.13 PIC16F873 Circuit Schematic

3.3.2 LCD Display

PIC is a powerful microcontroller that can handle integrated systems yet it is still lack of a display that could provide information especially dealing with ADC where the quantization numbers produce need to be determined practically and being illustrated as desire. A simple alphanumeric display to output text messages and numeric values of variables could enhance the versatility and usefulness of a microcontroller [5]. In this project, a LCD display being used to display the ADC data's.

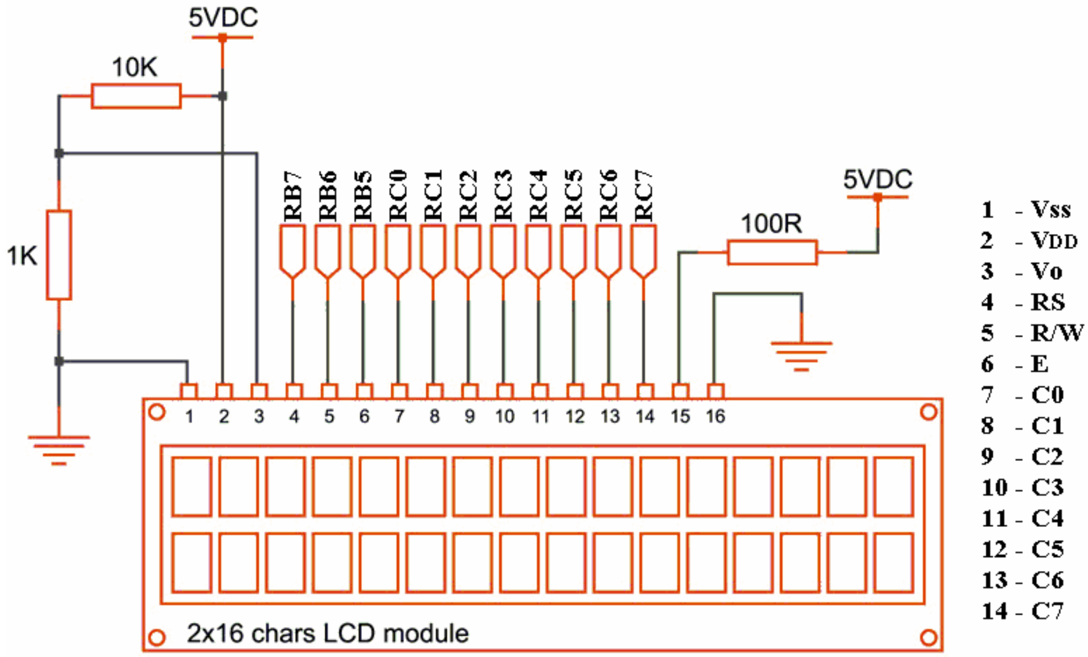

Figure 3.14 LCD Display Schematic Circuit

3.4 Firmware Development

The software editor used in this project is MicroCode Studio-Mecanique, 2005 which support the compiler for PICBASIC programming. The purposes of programming are to determine the function of the PIC16F873 pins and setting the analog-to-digital (ADC) system configuration.

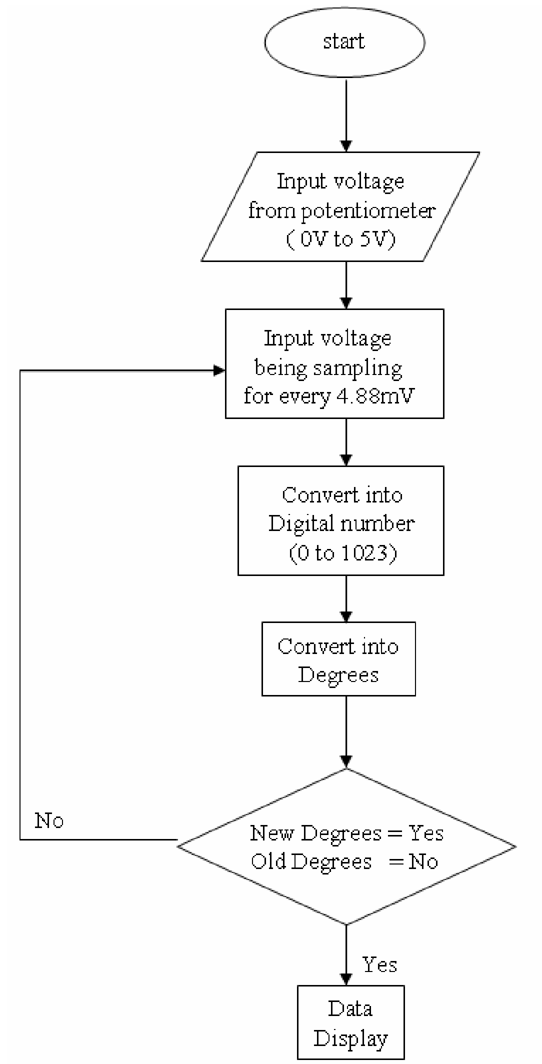

Figure 3.15 Firmware Programming Flow Chart

Figure 3.15 show the programming flow chart of the arm-glove notification system. Input voltage given to the electronic circuit system of the motion notification from the arm-glove. The analog input voltage being sample for every increment or decrement of 4.88mV. After the sampling process, it is being converts into digital form of number ranging from 0 to 1023. The converted digital number then being converts into degrees and appears at the LCD display. If there is no new input voltage, the previous data will remain appear at the LCD display. When there is new data, it will be transmitted to the LCD display replacing the previous data.

CHAPTER 4

RESULT & ANALYSIS

3.5 Mechanical Arm-Glove

Analysis shows that the arm-glove gives a full freedom towards the natural motion of the human arm except for a position of closing of the arm pit. This due to the thickness of the material used which is the PVC pipe. Meanwhile for the sensors, there is limitation of rotation towards the potentiometer. This because the angle of movement ranges of for X-Y and Y-Z axis is between 0 degrees to 90 degrees. Therefore, limitation towards sampling the voltage via resistance exists.

3.6 Human Arm Movement Notification System

Analysis shows that the human movement notification system only manages to display the ADC value of the X-Y axis but in unstable range of number. As the potentiometer 1 (for X-Y axis) increasing, the digital number will quickly increase form zero until a certain point where the number changing rapidly and become unstable number in the range of 1000 to 1023. Meanwhile for Y-Z axis, the digital number will always appear the number of 1023 even tough the potentiometer 2 (for Y-Z axis) being variable. It is as if there is a short circuit in the electronic systems that accidentally supply the input voltage towards the ADC Y-Z axis system and neglect the input from potentiometer 2.

From the analysis of human arm movement notification system performance, there are 2 possibilities that make the failures occur to the system. They are:-

i. The demand for accurate programming as stated in the datasheet where it can leads to the malfunction of the PIC16F873 ADC system if the procedure is not follow correctly.
ii. There is short circuit in the electronic circuit system since the constructed circuit is very small due to the mini and portable characteristic needed in order for the circuit to be attached at the mechanical arm-glove.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Conclusion

As the conclusion, this project almost manages to achieve the objectives which are fabricating suitable arm-glove that attach with sensors that can detect the specific movement of human arm and to develop an arm movement notification using microcontroller.

5.2 Recommendation

There are several ideas can be take into consideration to maximize the arm-glove notification system potential. Firstly the arm-glove where it can be constructs using plastic molding instead of using woods and PVC pipes. The advantages from using the material will make the arm-glove more users friendly and more ergonomic looks thus will maximize the movement freedom of the human arm since unnecessary parts and designs can be eliminate. The arm-glove also should be design where it can fit any physical size of human arm. Secondly, construct the electronic circuit using PCB plotting machine to make it more compact, error-free towards assembling the electronic component and neater to be put on the arm-glove.

For future project, this project could be adapted to design another glove that could detect the motion of other type of human body parts such as legs, finger and shoulder. This system also should be applied to control motion of motor in order to achieve the target of cybernetics.

5.3 Costing & Commercialization

The overall cost of the whole project is based on the hardware and modeling development. As discussed in chapter 3, the project development consist of 3 systems but costing of the whole project is surely depends of the electronic circuit (hardware) and mechanical arm-glove (modeling). Table 5.1 shows the overall cost for the hardware development and Table 5.2 shows the overall cost for modeling development.

Table 5.1 List of Hardware Development Costing

No.	Item	Specification	Quantity	Price Per Unit (RM)	Total (RM)
1	Wood	(0.5x 2.5)cm	7 feet	2.50	2.50
2	PVC Pipe	4 inch	1 feet	3.00	3.00
3	PVC Pipe	3 inch	1 feet	2.00	2.00
4	Screws & Nuts	1.5 cm	20 set	0.10	2.00
5	Screws & Nuts	1 cm	20 set	0.10	2.00
6	Hasp	-	1	1.50	1.50
Total					13.00

Table 5.2 List of Modeling Development Total Costing

No.	Item	Specification	Quantity	Price Per Unit (RM)	Total (RM)
1	Strip Board	-	1	8.00	8.00
2	Resistor	10kΩ	3	0.30	0.90
3	Resistor	1 kΩ	1	0.30	0.30
4	Potentiometer	10kΩ	2	2.50	5.00

5	Crystal	12MHz	1	8.00	8.00
6	Capacitor	100ηF	1	0.30	0.30
7	Capacitor	470uF, 50V	1	0.30	0.30
8	Capacitor	100uF, 50V	1	0.30	0.30
9	Microcontroller	PIC16F873	1	30.00	30.00
10	Voltage Regulator	LM7805	1	2.50	2.50
11	Heat Sink	-	1	1.50	1.50
12	LCD Display	VCM 162A	1	30.00	30.00
13	Serial Bus Wire	16 Lines	1 Meter	4.00	4.00
14	Connector	16 Pin	1 Set	3.50	3.70
15	9V Battery Cap	-	1	0.30	0.50
16	Push Button Switch	-	1	0.50	0.50
17	Wire Jumper	-	2 Meter	1.00	1.20
Total					97.00

The total cost for the project development is RM 110.00. This project cannot be commercialized since it is a part of research towards developing machine mechanical movement via human biology movement. Therefore, further research and continuous development towards this project is vital in order to bring growth in cybernetics knowledge and commercialize the technology in the future.

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APPENDIX A

PBasic Programming

```
'*************************************************************
'*  Name    : Arm-Glove ADC.BAS                              *
'*  Author  : Mohd Hazrul Bin Mohd Rusli                     *
'*  Notice  : Copyright (c) 2007 [select VIEW...EDITOR OPTIONS] *
'*          : All Rights Reserved                            *
'*  Date    : 10/10/2007                                     *
'*  Version : 1.0                                            *
'*************************************************************


DEFINE  OSC 20                          'Using 20MHz crystal
DEFINE  LCD_DREG        PORTC           'LCD data port @ PORT C
DEFINE  LCD_DBIT 0                      'LCD data starting bit 0 or 4
DEFINE  LCD_RSREG       PORTB           'LCD register select port
DEFINE  LCD_RSBIT       5               'LCD register select bit
DEFINE  LCD_EREG        PORTB           'LCD enable port
DEFINE  LCD_EBIT 7                      'LCD enable bit
DEFINE  LCD_RWREG       PORTB           'LCD read/write port
DEFINE  LCD_RWBIT       6               'LCD read/write bit
DEFINE  LCD_BITS 8                      'LCD bus size 4 or 8
DEFINE  LCD_LINES       2               'Number lines on LCD
adval1  var word                        'Create adval to store result
adval2  var word                        'Create adval to store result
catch1 var word
catch2 var word
TRISA  = %11111111      ' Set PORTA to all input
ADCON1 = %10000010      ' Set PORTA analog and RIGHT justify result

catch1=0
catch2=0
```

```
adval1=1                                   'Create adval to store result
adval2=1                                   'Create adval to store result

pause   2000                                        'Wait until the LCD initializes
      LCDOUT  $FE, 1                                'Clear LCD screen
      LCDOUT  $FE,$80," AGNiSys "         '1st line-display title of the project
      LCDOUT  $FE,$C0,"by hazrul"        '2nd line-display author
      pause   2000
      LCDOUT  $FE, 1                                'Clear LCD screen
      LCDOUT  $FE,$C0,"     V 1.00"          '2nd line-display version
      pause   2000
      LCDOUT  $FE,$C0,"    PSM 2007"      '2nd line-display PSM 2007
      pause   2000
      LCDOUT  $FE,$C0,"     U M P  "         '2nd line-display UMP
      pause   2000
      LCDOUT  $FE, 1                                'Clear LCD screen

main:
   gosub getdisplaych0                         'goto subroutine for Channel A.0
   gosub getdisplaych1                         'goto subroutine for Channel A.1
goto main


' Subroutine to get A/D on Channel A.0
getdisplaych0:
   IF adval        = catch1 THEN GOTO main
   ADCON0     = %11000001                   'Set ADC for Channel A.0
   ADCON0.2  = 1                                'Start conversion for Channel A.0
   adval           = 0                                'Clear  adval
   adval1.HighByte = ADRESH               'move HIGH byte of result to adval
   adval1.LowByte = ADRESL                'move LOW byte of result to adval
   catch1 = adval1
   LCDOUT $fe, $80
   LCDOUT "X-Y:", DEC adval1                 'Display the decimal value
```

```
    pause 100
return

' Subroutine to get A/D on Channel A.0

 getdisplaych1:
     IF adval2 = catch2 THEN GOTO main
     ADCON0 = %11101001                    'Set ADC for Channel A.1
     ADCON0.2 = 1                          'Start conversion for Channel A.1
     adval2 = 0                            'Clear  adval2
     adval2.HighByte = ADRESH              'move HIGH byte of result to adval
     adval2.LowByte = ADRESL               'move LOW byte of result to adval
     catch2 = adval2
     LCDOUT $fe, $C0
     LCDOUT "Y-Z:", DEC adval2              'Display the decimal value
     pause 100
     return
```

APPENDIX B

Electronic Circuit Schematic