APPLICATION OF MICROCONTROLLER TO CONTROL PNEUMATIC ACTUATOR

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JUDUL: **APPLICATION OF MICROCONTROLLER TO CONTROL PNEUMATIC ACTUATOR**

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The automation systems that use electro-pneumatic technology are formed by mainly three kinds of elements: actuators or motors, sensors or buttons and control elements. Nowadays, most of the control elements in the industries use PLC to execute the logic of the system. Sensors and switches are designed as inputs and the direct control valves for the actuators are designed as outputs. All the logic necessary to the sequence of the movements, simulates other components like counter, timer and control the status of the system is based on internal programmed. With the use of the PLC, the project wins agility, because it is possible to create and simulate the system as many times as needed. (Nyein A.A, 2008). Therefore time can be saved, risk of mistakes can be reduced and complexity can be increased using the same elements.

However, an alternative in this case is to create a specific controller that can offer the exact size and resources that the project needs. This is made using microcontrollers as the base of this controller. The controller, which is made with the utilization of microcontroller, can be very specific and adapted to only one kind of machine or it can work as a generic controller that can be programmed as a usual PLC and work with logic that can be changed. All these characteristics depend on what is needed and how much experience the designer has in developing an electronic circuit and a program for microcontroller

1.2 PROBLEM STATEMENT

The PLC has come a long way from its development and establishment since its ability to work in any conditions and make it the only choice when process control is required. However, in some applications, the PLC offers too many resources that are not even used to control the system especially for small sized system. Problems with the PLC are as identified below:

i. Existed PLC is expensive for small system.
ii. Larger space required to place it.
iii. High voltage used.
iv. Difficult to change the existed control system.

1.3 PROJECT OBJECTIVES

The objectives of this project are to:

i. Build PIC circuit to control valves sequences and counter to move pneumatic actuator.
ii. Integrate PIC with pneumatic system.
iii. Reduce price of existed PLC controller system.
iv. Compare the price with existed PLC.

1.4 PROJECT SCOPES

In order to achieve objectives of this project, certain scopes have been outlined. The scopes are:

i. System must consists of three linear cylinder double-acting actuators.
ii. Only functionality of microcontroller interacting with the actuators is evaluated.
iii. Motion and the movement planning application of the actuators is tested
iv. The system is a closed system.

1.5 OUTLINE OF THESIS

This thesis consists of four chapters. In first chapter, it describes overall framework of basic information of this project. In Chapter 2, it focuses various reviews on theoretical study to this project. It will discuss about the system and general info for each components involved.

While in Chapter 3, the method of research regarding on system description and the hardware and software implementation is elaborated. Pre-analysis on calculations that have been reviewed in Chapter 2 is shown in this chapter too. These calculations are vital for material selection. Finally, results and discussion will be discussed in Chapter 4 and conclusion and recommendation will be provided in Chapter 5.

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter concerns on basic principles of controller system. Also, it covers on general information on PLC and microcontroller which commonly known as PIC. It also includes basic study on components involved in pneumatic system for further understanding of this project. The facts and information gained from reliable sources and is elaborated based on understanding of the review.

2.2 CONTROLLER

Controller is indeed important to manage, command, direct or regulate the behaviour of other devices or systems. Feedback controls are widely used in modern automated systems. A feedback control system consists of five basic components: (1) input, (2) process being controlled, (3) output, (4) sensing elements, and (5) controller and actuating devices as output. Figure 2.1 below illustrates the commonly used feedback controls system.

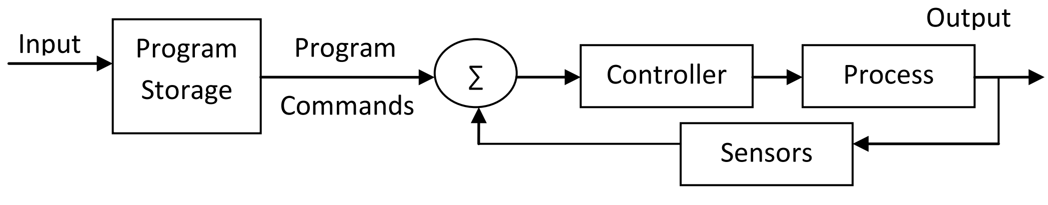

Figure 2.1 : Feedback controls system

Commonly used controller to control logic circuit is PLC. However, there is a new idea to replace this PLC with more compact and smaller controller that is called PIC. Quick review on PLC and PIC are shown as below.

2.2.1 Quick Review on PLC and PIC

In this subchapter, history of PIC and PLC and their working principles will be provided. Yet, advantages and disadvantages for PLC and PIC are more focused on. All the information provided will be summarized into a table based on their criteria.

2.2.1.1 Programmable Logic Controller (PLC)

Programmable Logic Controller was invented to replace relay control systems. More improvements to PLC occurred in the 1970's and 1980's. In the 70's, the ability to communicate between PLC was added. This also made it possible to have the controlling circuit quite a ways away from the machine it was controlling. While in the 1980's, the size of PLCs was reduced to use space more efficiently. (Amunrud A, 2002)

A PLC generally does three basic things: check the inputs, run through the program, and change the outputs. It then loops back to the top and starts again. It is fundamentally a relay control systems that is combine into a package. This means that a PLC is consist of:

i. Input and output relays: send and receive information from the outside world.
ii. Counters: how fast the PLC counters the information.
iii. Timers: how long the output stays changed once the input is provided.
iv. Data storage registers: save data after programming.

PLCs are very good for controlling outputs depending on inputs. They are remarkably robust, and able to stand all sorts of difficult conditions, such as extreme temperatures or dust in the air. It can withstand 0°C to 60°C during operating. They do not have contacts that wear out. They also can switch fairly quickly without heating up much, in direct contrast to relays. This means that cooling costs are decreased.

On the downside, PLCs are not very good at handling large amount of data, or complex data. There is limited amount of data storage. Plus, user cannot simply choose any i/o as input or output. Amount of inputs and outputs are set up by the manufacturer.

2.2.1.2 Programmable Interface Controller (PIC)

Microcontroller has gained its popularity among control systems builders due to its size, cost and the performance of the microcontroller which is way better compared to the existed control system.

A microcontroller is the combination of a microprocessor, memory, input and output ports and some of the special functions like timer, analogue to digital converter, mathematics processor and PWM generator in one chip. A microcontroller will take an input from a device it is controlling hence controls the device by sending signals to different components in the device.

Due to the availability of a number of resources such as multiple input-output, timers, serial interface and others, the microcontroller is today used for number of front end applications and stand alone systems. It is now tradition to convert analog and digital circuits to microcontroller based system because of the additional advantages provided by the microcontroller, such as:

i. ability and ease of computation.
ii. relatively small size.
iii. reasonable cost.

Their temperature properties depend on the manufacturer. Normally they can withstand temperature from 0°C to 80°C during operating. [Dole N.E, 2003]

2.2.2 Difference Between PLC and PIC

Based on general review on PIC and PLC, their different properties can be simplified into Table 2.1.

Table 2.1 : Comparison between PIC and PLC

Properties	**PIC**	**PLC**
Cost	Cheap	Expensive
Size	Smaller	Bulky
Board Area	Can be reduced	Need large area compare to PIC
Programming	Easy to change programme	Changing the program requires physically moving the existed PLC.
Handle Complex Command At One Time	Easier	Difficult
Ease of Design	Simpler	Harder
Can choose any i/o as output	Yes	No
Required Voltage	5V	12V,24V
Temperature	0-80°C	0-60°C
Maintenance Cost	Low	High. Require Specialist

2.3 ELECTRO-PNEUMATIC SYSTEM

Generally, pneumatics deal with systems that operated with highly compressed air or inert gases to impart power. It can also be defined as the study of movement of air.

Fundamentally, pneumatic system is applying force to a gaseous fluid like air and transmits pneumatic pressure all through the fluid and converting the stored energy back into mechanical force, before work could be done. The automation systems that use electro-pneumatic technology are formed by mainly three kinds of elements:

i. Power source
ii. Control Valve
iii. Actuator

The basic elements of a pneumatic system are depicted in Figure 2.2.

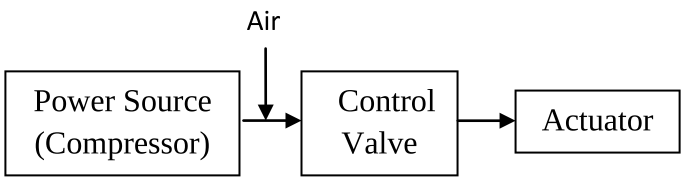

Figure 2.2 : Basic elements of a pneumatic system

Compressor reacts as a power source that increases the pressure of the air to provide power to move the actuator. The control valves will control the direction; flow and pressure of the actuator hence regulate the flow of pressurized air from compressors to actuators. This valve can be actuated manually, pneumatically or electrically depending on the design.

2.3.1 Power Source

Power is required to convert energy from one form to other convenient form and then transfer it to the point where power is required. The power medium must be suitable for the machine where work is to be done.

For pneumatic cases, compressor is the heart of any pneumatic system where it converts mechanical energy to pneumatic energy by generating compressed air. However, the compressed air generated is contaminated. Process to contaminants in the compressed air is called as ‘preparation’ or ‘conditioning’.

2.3.2 Control Valve

In pneumatic system, valve is a device that controls the flow direction and pressure of compressed air. Valve is important to regulate amount of the compressed air to supply to actuator. There are various types of valves. In terms of function, it can be classified into:

i. Directional control valves : Control the flow direction of compressed air.
ii. Non-return valves : Allow flow of compressed only in one direction.
iii. Pressure control valves : Limit the pressure of compressed air supplied.
iv. Flow control valves : Restrict the compressed air to reduce its flow rate.

However, this project only concern on directional control solenoid valves since this project main components are utilizing electrical signal to control flow of compressed air and movement of the actuator.

2.3.2.1 Ports and Positions

Directional control valves are differentiated on the number of ports and valve position. It is generally satisfied as ‘port/position valve’. Port refers to number of ports while position valve refers to number of switching position for the valve.

For instance, a 5/2 single solenoid valve as illustrated in Figure 2.3 has 5 ports and 2 switching positions. Right-hand square commonly represents normal position while the left-hand square refers to actuated position.

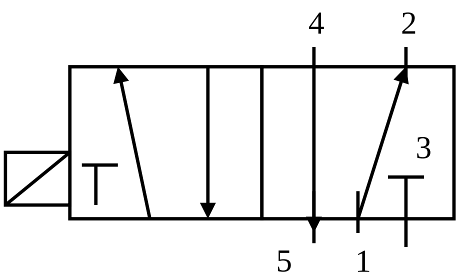

Figure 2.3 : 5/2 valve illustrated

Table 2.2 : Port markings of directional control valves

Port	Number System	Comment
Pressure Port	1	Supply port
Working Port	2	3/2 DC valve
Working Ports	2, 4	5/2 DC valve
Exhaust Port	3	3/2 DC valve
Exhaust Ports	5, 3	5/2 DC valve

Table 2.2 explains that 3/2 DC valve is different with 5/2 DC valve. There are two working ports for 5/2 DC valve which commonly called as port 2 and port 4 while for 3/2 DC valve there is only one working port which is port 1. This is also valid for exhaust port for both type of DC valve respectively.

2.3.2.2 Function Principle

A solenoid valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically.

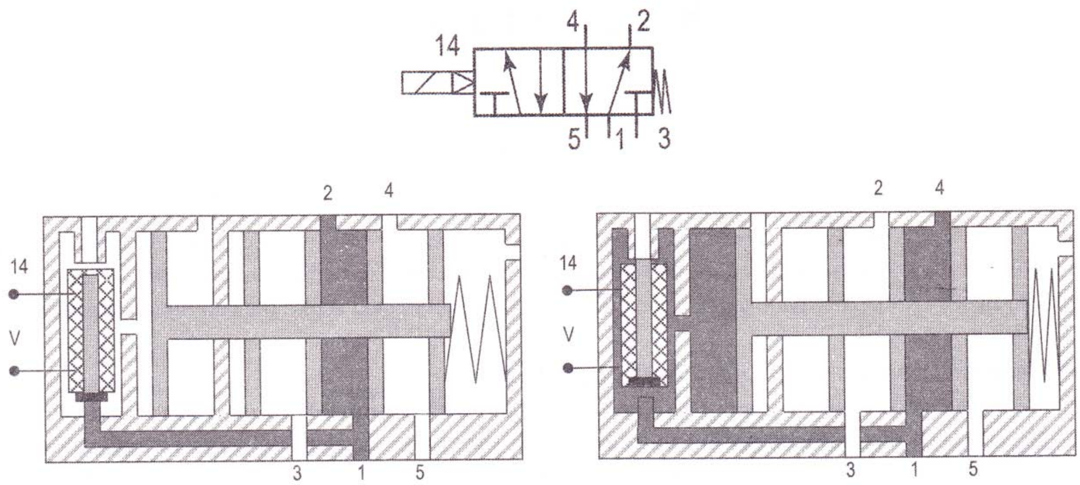

Figure 2.4 : 5/2 Ways Solenoid Spring Return Valve

Source : Joji, P. (2010)

From Figure 2.4, in normal position, port 1 is connected to port 2, port 4 is connected to port 5, and port 3 is blocked. When voltage is applied to the coil 14 shown above, the valve will be actuated. In this actuated position, port 1 is connected to port 4, port 2 is connected to port 3, and port 5 is blocked. The spring valve will force the port to return to its normal position when applied voltage is removed.

Figure 2.5 illustrates the movement of actuator before and after the coil of the 4/2 way single solenoid valve is actuated.

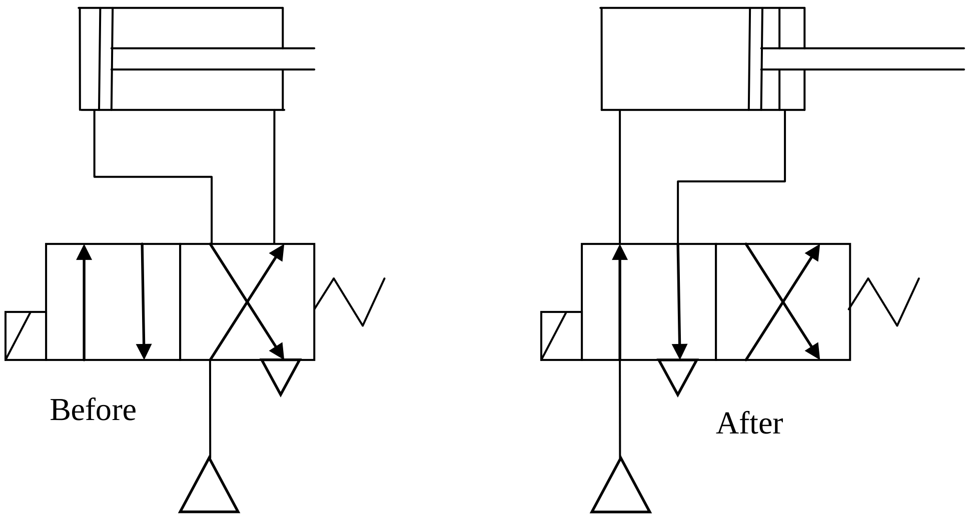

Figure 2.5 Movement of actuator before and after coil is actuated

After the solenoid valve has been activated, the coil at the solenoid valve is activated and it will pull the port to change the position. The new position will supply port to extend the actuator.

2.3.3 ACTUATOR

Pneumatic actuator is one of the important parts in this project. It is an output device that converts energy contained in the compressed air into motion. Basically, pneumatic actuators can be categorized into two types which are linear actuators that convert pneumatic energy into straight line mechanical energy and rotary actuators that convert pneumatic energy into rotary mechanical energy. (Joji, P. 2010). Basic function of pneumatic actuator and formula in calculating measurement of thrust are shown here.

2.3.3.1 Basic Actuator Functioning

An elementary cylinder consists of a body containing a movable piston of diameter D and a rod of diameter d connected to the piston. A basic linear double acting actuator is shown in Figure 2.6. A double-acting cylinder has two ports which air can enter or exit. When pressure is applied to port X, with port Y venting, the piston extends with a thrust force equal to the applied pressure. Similarly, if pressure is applied to port Y, with port X venting, the piston retracts with a pull force equal to the applied pressure.

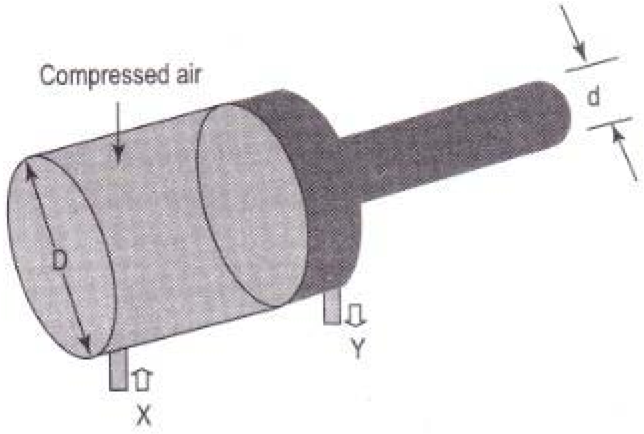

Figure 2.6 : A pneumatic cylinder

Source : Joji, P. (2000)

2.3.3.2 Measurement of Force

Measurement of thrust is to measure the amount of force that the cylinder can push or handle based on the amount of pressure supply and size of the actuator. The theoretical thrust (outstroke) or pull (in stroke) of a cylinder is calculated by multiplying the effective area of the piston by the working pressure. The effective area for thrust is the full area of the cylinder bore "D". The effective area for pull is reduced by the cross section area of the piston rod diameter "d".

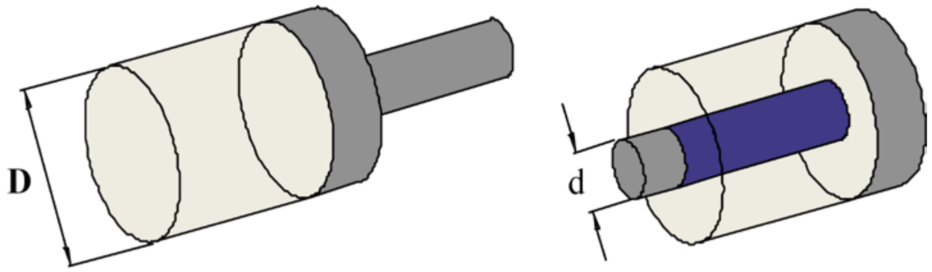

Figure 2.7 : Thrust in pneumatic cylinder

Source : Norgren (2010)

In the formula, P is divided by 10 to convert bar to Newton per square millimetre (1 bar = 0.1 N/mm^2)

$$\text{Thrust} = F = \frac{\pi}{4} D^2 \frac{P}{10} \text{ N} \quad (2.1)$$

D = Cylinder bore in millimeters

P = Pressure in bar

F = Thrust or pull in Newton

Pulling force F will be less than the thrust due to the area lost to the piston rod :

$$\text{Pull Force} = F = \frac{\pi(D^2 - d^2)P}{40} \quad (2.2)$$

D = Cylinder bore in millimetres

d = Piston rod diameter in millimetres

P = Pressure in bar

F = Thrust or Pull in Newton

2.3.4 SENSOR

A sensor is a device for converting a physical variable, such as distance, pressure, temperature. A sensor can detect whether a particular operation or event in the system has been complete or not, and then it can generate an output signal to indicate this detection. This signal can be fed back to the associated system controller for triggering the start of the next action.

For pneumatic actuator, commonly used sensor type is magnetic sensor. This magnetic sensor will detect electromagnetic in the actuator when cylinder moves. After the cylinder moves, this sensor will completed it circuit then send electrical signal to the system controller.

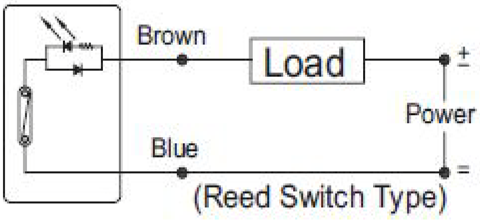

Figure 2.8 : Magnetic sensor circuit

Source : JRT (2010)

Figure 2.8 shows the standard Reed Switch type magnetic sensor. Brown wire is connected to positive (+) DC power source and the blue wire is connected to the controller to detect the sensor. For solid-type sensors, the power supply must be in DC power source (Jrtfa, 2010).

2.4 RELAY

A relay is an electromechanical switch. Relays are used to switch voltages and electronic signals. No human interaction is required for the switching to occur. The electronic pulses will perform the switching.

Basically, a relay operates based on the principals of electromagnetic. Inside a relay, there is a wire coil that will generate a magnetic field when there is electric pulse flows around it.

The relay is on when an electric pulse is sent to the relay, the swing or switching arm of the switch moves to another contact of the switch. The arm moves as the generated magnetic field pulls the swinging arm toward the inductor (or wire coil). More illustrated regarding to its basic principles is elaborated below.

2.4.1 Basic Principles

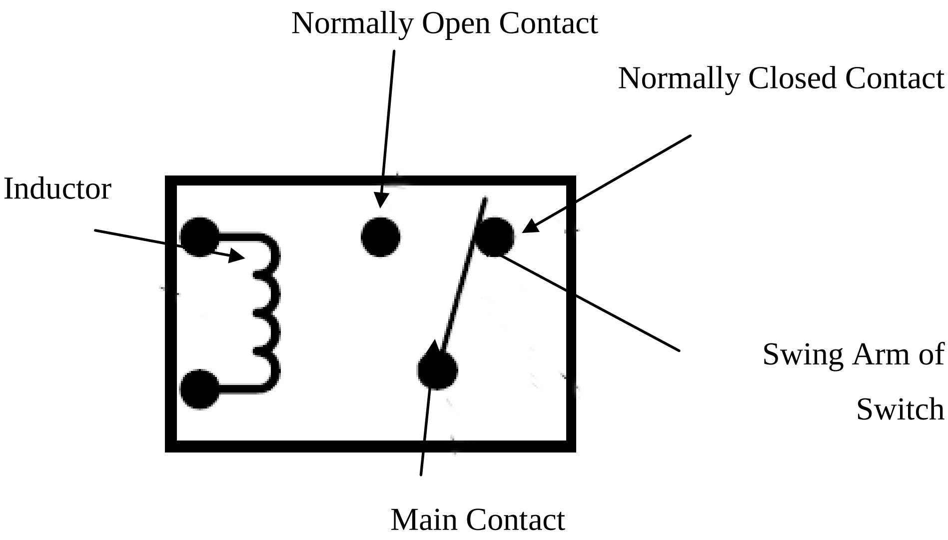

Figure 2.9 : Basic relay

Source : The Install Doctor (1998)

i. Inductor (wire coil)

One contact is connected to (-) ground and the other are connected to a wire which only turns (+) positive when triggered Inductor coils are neutral in electric terms. Either end can be (+) positive or (-) negative. But neither end can be both at the same time or the relay will not operate.

ii. Normally Open Contact

In contact with the swing arm when the relay is on.

iii. Normally Closed Contact

In contact with the swing arm when the relay is off.

iv. Main Contact

Attached to swing arm

v. Swing Arm of Switch

When the relay is off, the arm is at rest against the "normally closed contact".

2.4.2 Types of Relay

There are various types of relays out there in the market. However, there are only three types of relays that are commonly used. They are Single Pole Single Throw (SPST) Relay and Single Pole Double Throw Relay (SPDT).

2.4.2.1 Single Pole Single Throw (SPST)

A very popular automotive relay is a little black cube about an inch on a side. If it has 4 prongs, it is called a Single Pole, Single Throw. Number 30 and 87 is in normally open condition while its actuating coil is located between prong number 85 and 86.

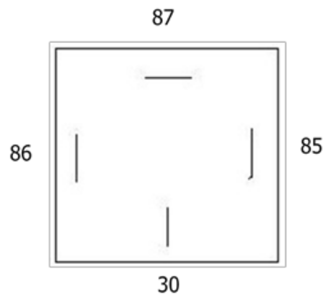

Figure 2.10 : SPST Symbol

Source : Jones, C. (2008)

2.4.2.2 Single Pole Double Throw (SPDT)

SPST will become SPDT relay when an 87a prong is added. The magnet coil is still located between prong 85 and 86. Common or negative commonly is supplied at terminal 30.

This relay can be used to either open a circuit or close a circuit, or it can be used to switch one circuit on through terminal 87 while switching another circuit off through prong 87a. These relays can handle 12 volts at some prescribed maximum amperage, usually 30 or 40 amps. A higher rating is better for longer life.

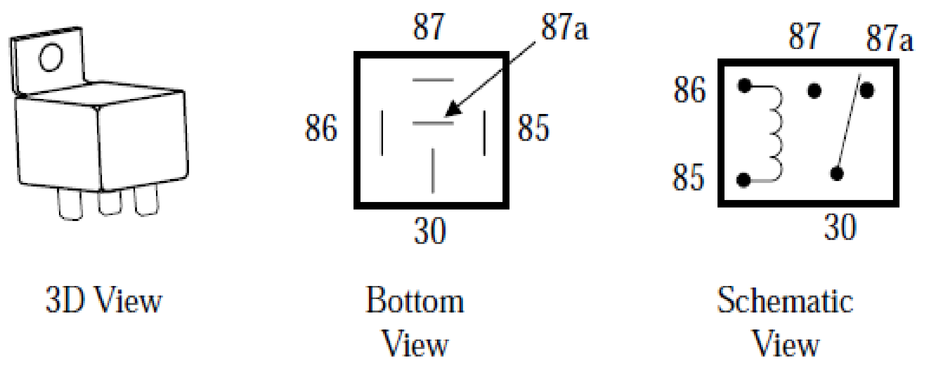

Figure 2.11 : SPDT Symbol

Source : The Install Doctor (1998)

2.5 TRANSISTORS CIRCUIT

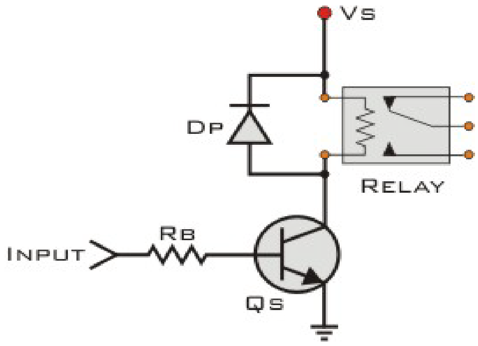

Figure 2.12 : Transistor circuit

Source : G. Lazaridis (2009)

Figure 2.12 shows the basic transistor relay driver, actuated on high input. The circuit will switch on relays at low power output such as a microcontroller. It is used to switch high loads or loads that need higher voltage to operate. The relay will be actuated during input of the circuit goes high. The protection diode, D_p is used to protect the transistor from the reverse current generated from the coil of the relay during the switch off time. Values for R_b and Q_s vary accordingly. The way to calculate the components is:

First the load current is calculated:

$$I_L = V_S / R_L \tag{2.3}$$

Then transistor current gain, h_{FE} is calculated. Its value must be at least 5 times the load current I_L divided by the maximum output current from the input to the base of the transistor.

$$h_{FE}(\text{min}) > \frac{5 \text{ X } I_L}{I_{INPUT}} \tag{2.4}$$

Next, base resistor R_B shall be calculated. If the input is taken from a component such as a microcontroller that uses the same power supply as the transistor (Vs), then the form is:

$$R_B = 0.2 \text{ X } R_L \text{ X } h_{FE} \tag{2.5}$$

Otherwise, if the component uses another power source (like V_{CC}) then the form is:

$$R_B = \frac{V_{CC} \text{ X } h_{FE}}{5 \text{ X } I_L} \tag{2.6}$$

All equations above are provided by G.Lazaridis (2009).

2.6 MICROCONTROLLER

A microcontroller is the combination of a microprocessor, memory, input and output ports and some of the special functions like timer, analogue to digital converter, mathematics processor and PWM generator in one chip. A microcontroller is a computer with most of the necessary support chips onboard. It has several things in common with computer, namely:

a) A central processing unit (CPU) that 'executes' programs.
b) Random-access memory (RAM) where it can store data that is variable.
c) Read only memory (ROM) where programs to be executed can be stored.
d) Input and output (I/O) devices that enable communication to be established with the outside world

There are countless of microcontroller in the market which range from 8 bit, 16 bit to the more advanced 32 bit. The higher the value of bit, more performance will be provided by the microcontroller. Designers can use a microcontroller to gather input from various sensors then command a set of functions or even use the output of microcontroller for something worth. A microcontroller is often small and low cost however it may be chosen to minimize size and to be as inexpensive as possible.

To build a basic microcontroller circuit, it must consist of 3 basic circuits (Jazari2u, 2010). These three circuits are crucial to build a microcontroller system.

i)

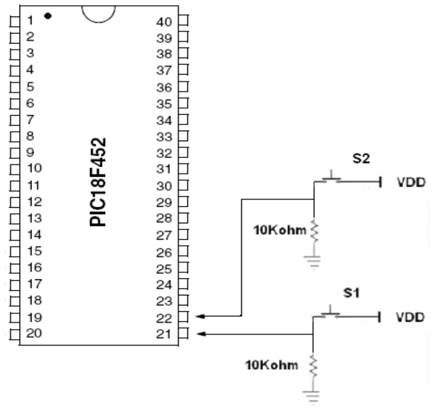

Figure 2.13 : Push button circuit

Push Button is used to reset the microcontroller to zero memory.

ii)

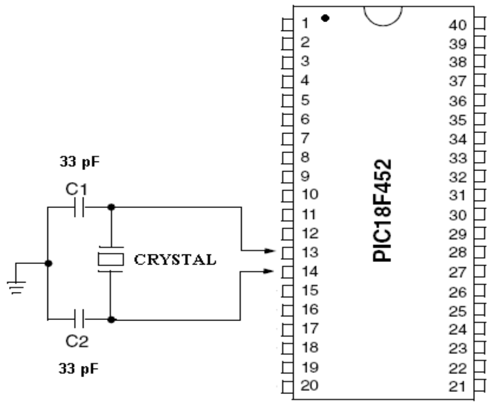

Figure 2.14 : Crystal circuit

Crystal Circuit will provide frequency to microcontroller.

iii)

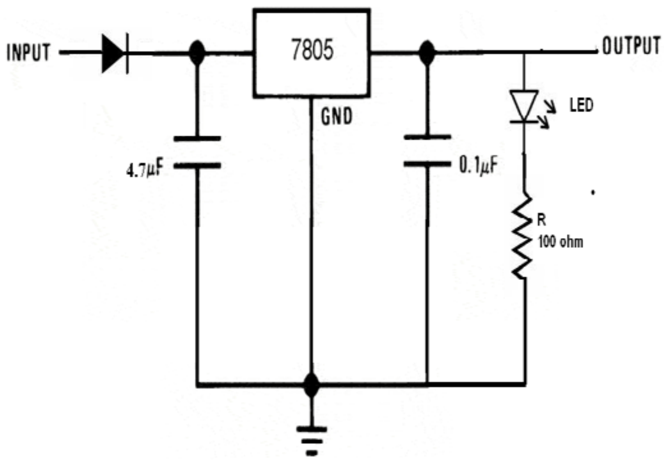

Figure 2.15 : Voltage regulator circuit

Voltage Regulator Circuit is crucial to maintain constant voltage 5V level to microcontroller and convert AC from computer to DC voltage.

2.7 PROGRAMMING

Machine language is the only language that a controller can understand. The language consists of instructions in binary code that is specific to the particular process for which it is to be used. Every step that the controller needs to take must be written in instructions.

2.7.1 Boolean Flow Control

Boolean Flow Control makes the program behaves in a particular manner depending on the input given to the program. It is required since in a controller, not all parts are executed all of the time. Below shows a basic if-else, else-if Boolean Flow Control structure.

```
if ( Condition1)
{
…..
}
else if (Condition2)
{
…..
}
else if (Condition3)
{
…..
}
else
{
…..
}
```

Figure 2.16 : If-else-if control structure

Source : D'orazio, T.B. and Tan, H.H.(1999)

Program structure above shifts program control, step by step, through a series of statement blocks. Control stops at the relational expression that is True and executes the corresponding statement block. If none of the relational expressions condition 1, condition 2, and condition 3 are true, the final statement 'else' block is executed.

2.7.2 Operator

Operator is a relational expression that compares the values of two arithmetic expressions. It is a type of logical expression and produces a result of either true or false. In C programming, there are 6 relational operators shows in Table 2.3.

Table 2.3 : C language relational operators

Relational Operator	Meaning
<	Less than
< =	Less than or equal to
= =	Equal to
>	Greater than
> =	Greater than or equal to
! =	Not equal to

Source : Striegel, A. and Rover, D. (2001)

2.8 COST

For any business, costs can be classified into two components which are fixed cost and variable cost. Fixed cost is that component which does not depend on the volume whereas variable cost is directly proportional to the volume. (Tutorvista, 2010) In other words, fixed costs remain the same regardless of the volume of sales, whereas variable costs are conversely.

Certain parts in Break-even analysis could be a useful technique for determining profit difference between two options of production cost. (UiTm Entrepreneuship Study Group. 2010). Variables involved and Break-even analysis formula is shown below:

c_f = Fixed cost

v = Volume (number of units produced)

c_v = Variable cost per unit

p = Price per unit

Total cost, TC = Fixed cost + Total variable cost

$$= c_f + vc_v \tag{2.7}$$

Total revenue, TR = Volume x Price

$$= vp \tag{2.8}$$

Profit, Z = Total revenue - Total cost

= TR - TC

$$= vp - (c_f + vc_v) \tag{2.9}$$

2.9 RELEVANCE OF THE LITERATURE REVIEW

The reviews help to generalize idea from the factual information that act as guidance towards the project. As for conclusion of this chapter, understanding the theory and principles in pneumatic system is crucial to decide the design for pneumatic application for this project. Basic circuit to build a microcontroller system and fundamentals of cost are significant to proceed with this project as to achieve all the project objectives. Through it, common idea toward methodological approach of the project can be obtained. Further details on the components selection and its general specification are elaborated on Chapter 3.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter will describe the method for the application of microcontroller in order to control pneumatic actuator. Project activity must be done step by step. It begins with searching, reviewing and understanding the basic principles of pneumatic system and electronic components first. Next, design process will took place for the application, system circuit and programming behavior to meet the main project requirement. Finally, the system is tested. Simplified flow for this project is shown as below.

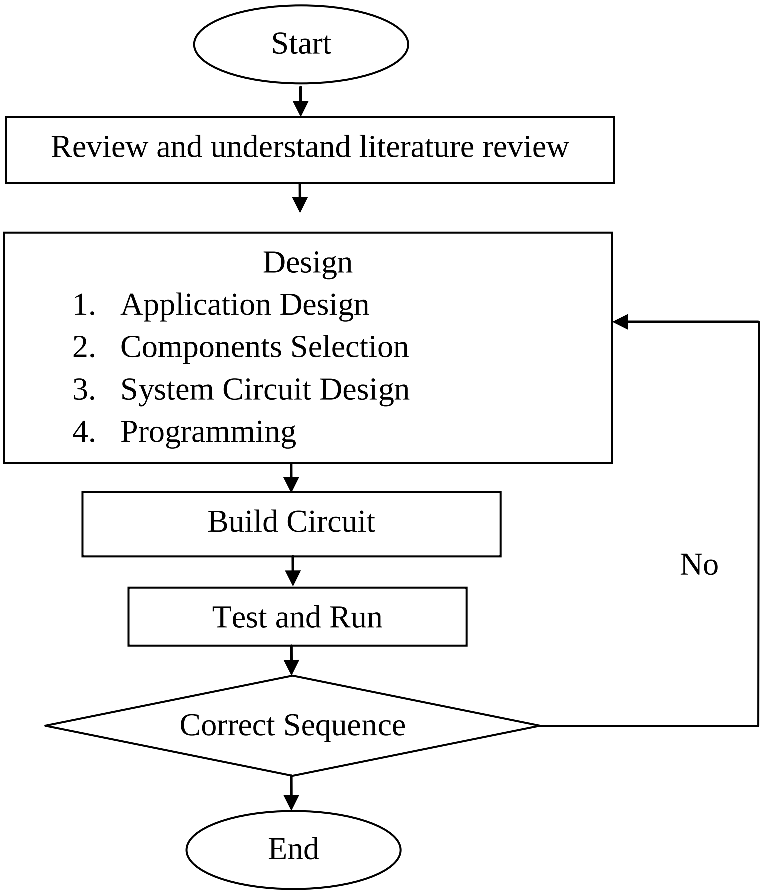

Figure 3.1 : Flow works

3.2 APPLICATION DESIGN

The application design is the backbone for the design process. It acts as pre-development stage before the detail specification and next process were executed. The movement sequence for the actuators will be based on this application design in which has been selected. Design of application for this project is shown here.

3.2.1 Drilling Machine Pneumatically Controlled

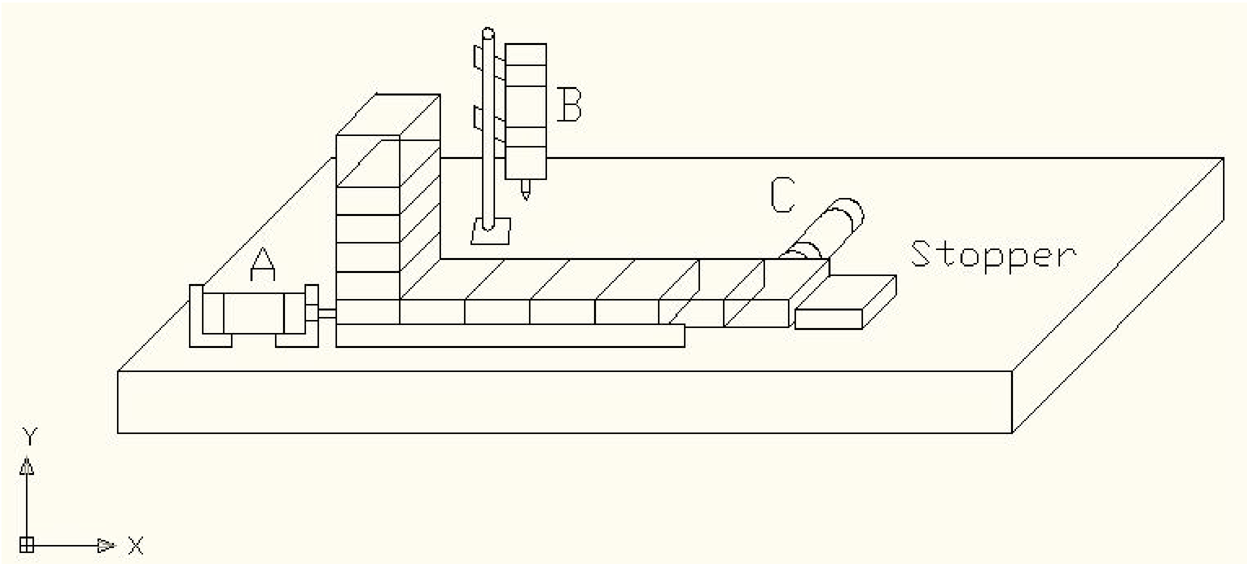

Figure 3.2 : Basic sketching of application design

The arrangement and installation of pneumatic cylinders for this project is shown in Figure 3.2. It is the application of drilling machine pneumatically controlled. This application involving 3 cylinders; cylinders A, B and C. Cylinder A will extend to move the rectangular-shaped work pieces. These work-pieces are arranged in a gravity feed magazine. After cylinder A pushed these work-pieces, it then will be drilled by cylinder B. Cylinder C will extend to transfer work-pieces to a box.

This application design will only be tested. For this project, only movements of the actuator are concerned and actuators must move according to the sequence flow.

3.2.2 Displacement-Step Diagram

Notations for the desired sequence of pneumatic actuator are represented by displacement-step diagram in Figure 3.3.

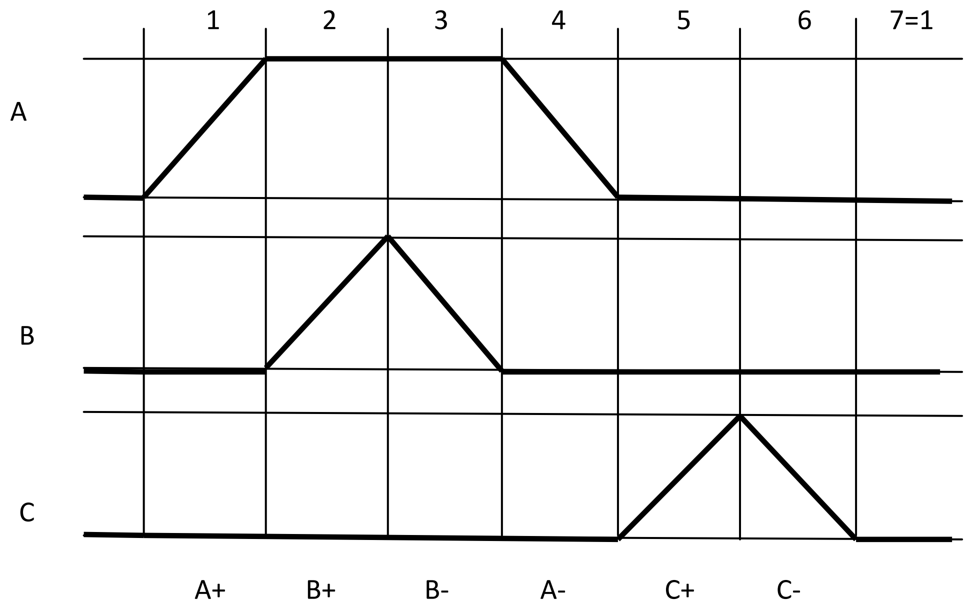

Figure 3.3 : Displacement-step diagram for the application

For the control task above, the sequence of cylinder actuated can be represented by :

A+ B+ B- A- C+ C-

Symbol '+' in the displacement-step diagram represents the forward motion of actuator while the '-' symbol represents the return motion of each actuator. All actuators must not be actuated at initial condition. It consist total of 7 sequence moves for cylinders A, B and C.

3.3 COMPONENT SELECTION

This section is mainly focus on the functions, properties and specifications of the components that had been selected for this project. Component selection is divided into two parts. First component is the mechanical components and second are electronic components. Components that had been chosen are based on the circuit design that is going to be elaborated under system circuit design.

3.3.1 Mechanical Components

There are three mechanical components involved in this project. They are solenoid valve, magnetic sensor and actuator. To control three actuators, actuator A, B, and C, it is required to have three solenoid valves to control each actuator movement. Sensors are used to send signal to microcontroller. Microcontroller will capture the signal from the sensor hence send voltage to the solenoid valve for next sequence move.

3.3.1.1 5/2 Way Single Solenoid Valve

5/2 way single solenoid valve with a spring return is used. Figure 3.4 shows the 5/2 way single solenoid valve with the complete wiring. The specification of 5/2 solenoid is provided in Table 3.1.

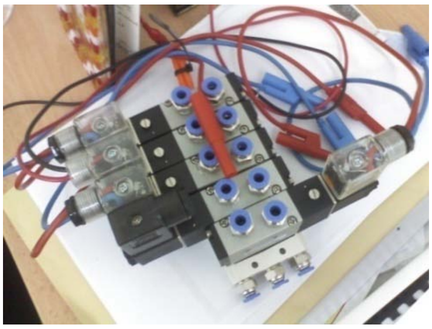

Figure 3.4 : 5/2 way single solenoid valve

Table 3.1 : General specification of valve selected

Properties	Specification
Manufacturer	MVSPC
Model	4V210-08
Ampere	200mA
Max Temperature	60°C
Voltage Rated	24V
Pressure Range	0.15 – 0.80 MPa

3.3.1.2 Double Acting Actuator

Pneumatic actuators are used to show sequences that have been programmed into the microcontroller. There are various types of pneumatic actuator in the market. However, it has been decided to use double-acting cylinder actuator since 5/2 way valve is selected.

The figure of the pneumatic actuator selected and its specification are shown in Figure 3.5 and Table 3.2 respectively.

Figure 3.5 XCPC pneumatic actuator

Table 3.2 : Specification of cylinder actuator

Properties	Specification
Manufacturer	XCPC
Model	SC40x50
Diameter	40mm
Length	50mm
Voltage Rated	24V
Max Pressure	1 MPa

3.3.1.3 Magnetic Sensor

Magnetic sensor is crucial to detect whether actuator has expand completely or vice versa. This magnetic sensor will send signal to the microcontroller in form electronic pulses. Microcontroller will received this signal and will proceed the next command. Type of magnetic sensor used is a reed switch type. Figure 3.6 shows the XCPC brand magnetic sensor used for this project. The magnetic sensor’s specification is provided in Table 3.3.

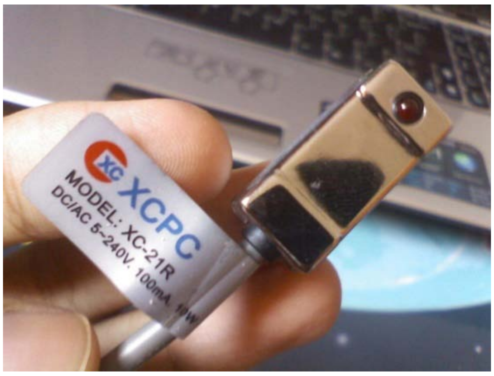

Figure 3.6 : XCPC magnetic sensor

Table 3.3 : Specification of magnetic sensor

Properties	Specification
Manufacturer	XCPC
Model	XC-21 R
Current Rated	100mA
Voltage Rated	5-240 V DC/AC

3.3.2 Electronic Components

Supplementary to microcontroller PIC18F452 is electronic components. Electronic components will interact with the microcontroller and complete design circuit that is going to be elaborated on system design circuit section.

3.3.2.1 PIC18F452

In this project, the PIC18F452 microcontroller has been chosen to be used to controls the pneumatic system actuation so that the pneumatic system actuation can actuate according to desired plan. This microcontroller consumes low power supply and voltage that is around 5 volt. Compare to other microcontroller, it has more number of ports so it can provides enough input and output for our system. Furthermore, it can support frequency as high as 20MHz. The specification and the figure of this unique microcontroller are shown in Figure 3.7 and Table 3.4.

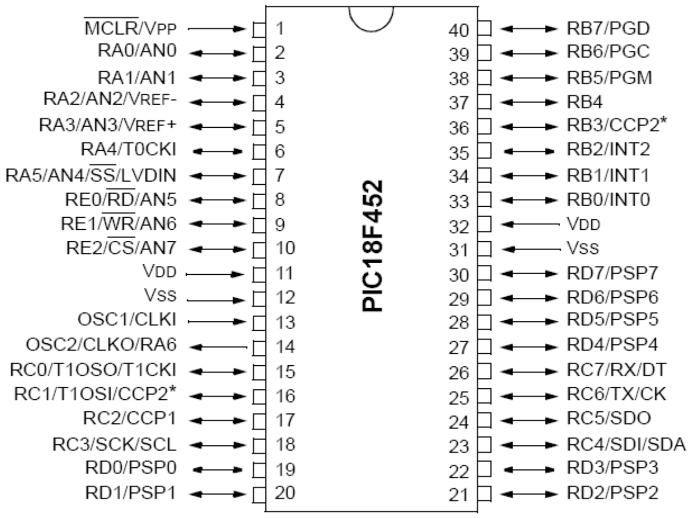

Figure 3.7 : Microcontroller PIC18F452

Table 3.4 : Features of PIC18F452

Features	Characteristics/Value
Architecture	16Bit
Program Memory Type	RAM
I/O	34
Max Speed (Mhz)	20
No of Pins	40

3.3.2.2 SPDT Relay

6 Voltage Single Pole Double Throw (SPDT) relay is used for switching purposes in this project. There is a need to switch 5V voltage from microcontroller to 24V in order to run the solenoid valve. SPDT relay is used in fabrication since it provides the simplest switching idea at low cost. Its operational current rating is 50mA.

Figure 3.8 : 6V SPDT relay

3.3.2.3 NPN Transistor

A NPN type transistor is used. Amount of current provided by the microcontroller is not sufficient to turn on the relay. For that reason, existence of transistor is acquired to ensure enough current flow to switch on relays for switching intention.

Figure 3.9 : General NPN transistor

3.3.2.4 Diode

In order to avoid high external DC voltage that might harm low voltage microcontroller, diode is used. This diode will only allow current to flow in only one direction hence prevent back voltage goes back into the microcontroller. General purpose diode, IN4007 is used as shown in Figure 3.10.

Figure 3.10 : IN4007 diode

3.4 SYSTEM CIRCUIT DESIGN

The circuit system design consists of layout of the overall system schematic diagram and details on electronic board circuit. The purpose of this electronic board circuit design is to design a circuit that can encounter inconveniences which are low current supply to switch on relays by the microcontroller and 5V to 24V switching purposes to run the solenoid valve. As the outcome, all these design will be implemented on the project board circuit and shall be connected to mechanical components.

3.4.1 Schematic System Diagram

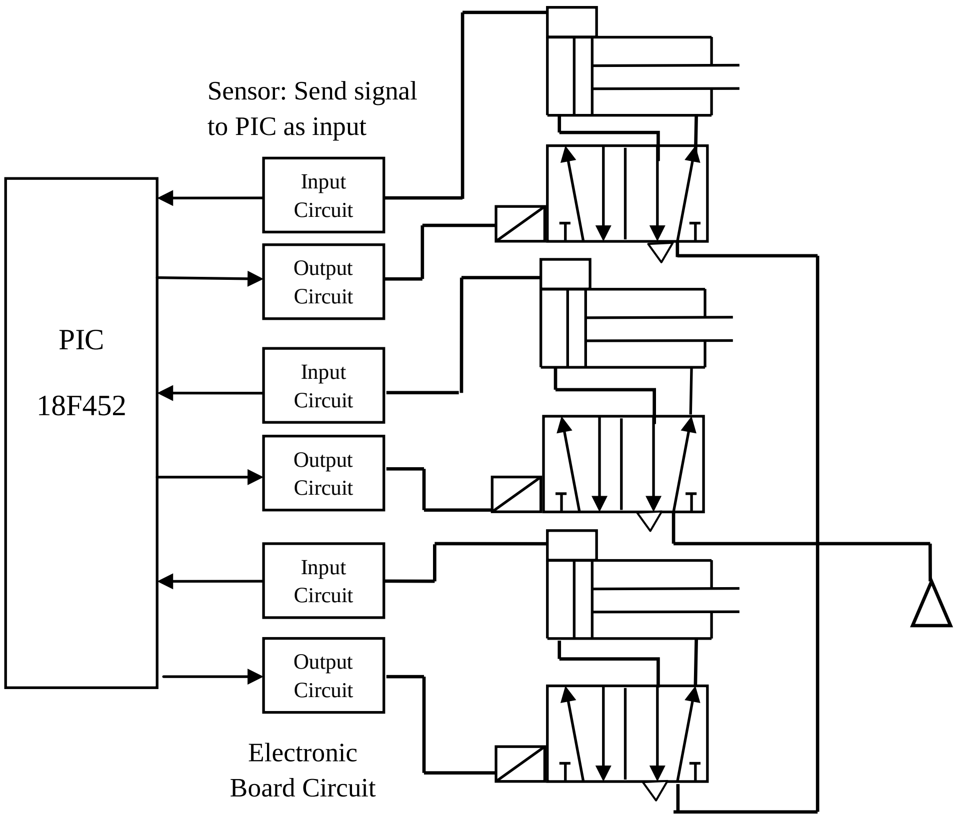

Figure 3.11 : Overall system schematic diagram

3.4.2 Electronic Board Circuit

There are basically three stages of electronic board circuit design for this project which are:

- **i.** Input circuit : sense input from sensor
- **ii.** Controller circuit : process the input to run the output
- **iii.** Output circuit : send voltage to solenoid valve

3.4.2.1 Input Circuit

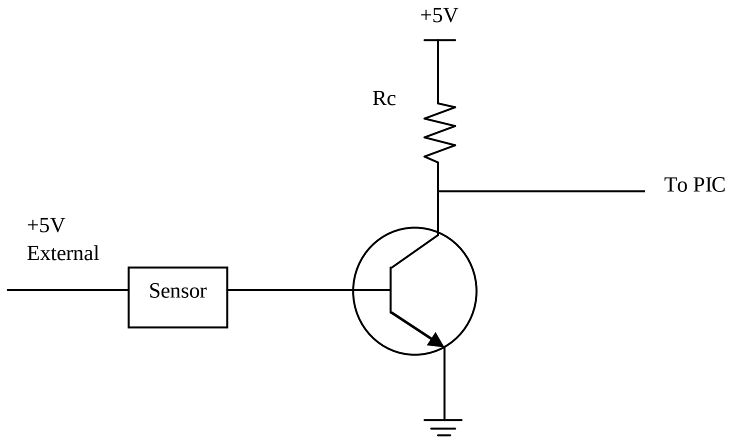

Figure 3.12 : Input sensor circuit

Principally, basic circuit design is created to provide low current to microcontroller to avoid the microcontroller from being harmed. Transistor reacts as a switch. When a current is supplied at the sensor, the transistor allows current to flow from pin microcontroller to ground (GND). The resistor will pull the current and force it to the ground. This flow changes will transform high logic ‘1’ from sensor to low logic ‘0’. Collector resistance, R_c is to minimize current flow by the sensor.

$R_c = V/I$

$= 5/25x10^{-3}$

$= 200\Omega$

Therefore, the minimum value of resistance must be 200 Ω. However, for safety circumstances, it is decided to use 1kΩ instead of 200Ω. This is to ensure no high current return to microcontroller.

3.4.2.2 Controller Circuit (PIC18F452)

As mentioned previously, microcontroller PIC18F452 is used for controlling predefined sequences of opening and closing of solenoid valves that will activate the actuator and catch signal from the magnetic sensor to move the next predefined sequences. The basic circuit that a microcontroller must have is shown in Figure 3.13.

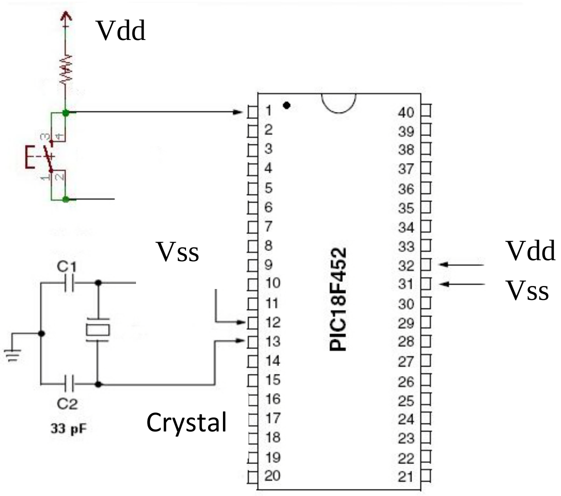

Figure 3.13 : Microcontroller basic circuit

For PIC18F452, it has 5 ports called Port A, Port B, Port C, Port D and Port E. For this project, only Port A and Port D are used. The function of each port that has been selected is simplified on table below. Generally, Port A will sense output from the magnetic sensor. Port D is used to send signal to solenoid valve in order to move pneumatic actuator.

Table 3.5 : Ports of PIC18F452 and its function

Port	Pin	Function
PORT A	RA0	Sense output from magnetic sensor cylinder A
	RA1	Sense output from magnetic sensor cylinder B
	RA2	Sense output from magnetic sensor cylinder C
PORT D	RD5	Send voltage to valve to actuate cylinder A
	RD6	Send voltage to valve to actuate cylinder B
	RD7	Send voltage to valve to actuate cylinder C

3.4.2.3 Output Circuit

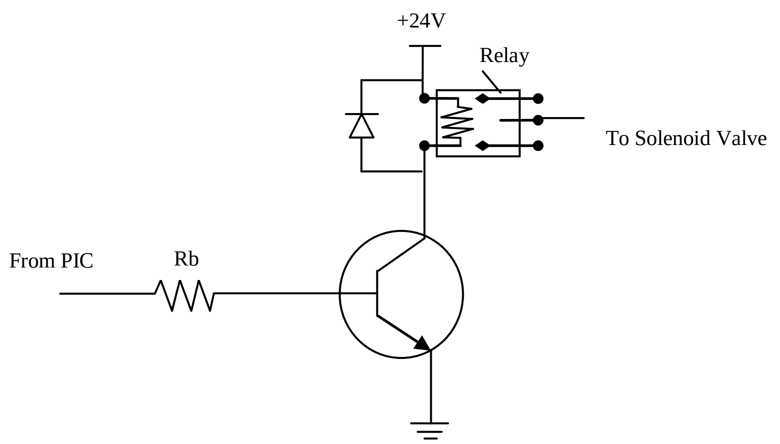

Figure 3.14 : Output circuit

Microcontroller rated ampere is 25mA. This 25mA is not sufficient enough to drive a relay of 50mA coil resistance. Therefore, output circuit above is design to drive the relay at low current output. The relay will be actuated using this circuit when microcontroller is sending signal. From this circuit, amount of base resistance, $R_b\Omega$ (ohm) needed must be calculated. The value of relay coil resistance needs to be determined first.

Relay coil resistance, R_L

= V/I

= 6/50mA

= 120 Ω

Current Load, I_L

= V_S / R_L

= 24/120

= 200mA

Transistor Current Gain, h_{FE}(min)

= 5 x (I_L/$I_{INPUT\ MICROCONTROLLER}$)

= 5 x (200mA/25mA)

= 40mA

Base Resistor, R_b

= (Vcc x h_{FE}) / (5x I_L)

= (5x40mA) / (5x200mA)

= 0.20 kΩ

= 200 Ω

Therefore, base resistor should be around 200 Ω. Nearest standard resistor chosen is resistor 330 Ω.

3.4.3 Circuit Summary

Based on all the circuits mentioned before, a table of total components involved for both mechanical and electronic components can be listed down.

Table 3.6 : Total components involved

Components	Number of Components
Microcontroller	1
Magnetic Sensor	3
DPDT 6V Relay	3
5/2 DC Solenoid Valve	3
Pneumatic Actuator	3
Transistor	6
Diode	3
330Ω Resistor	3
1kΩ Resistor	3

3.5 PROGRAMMING

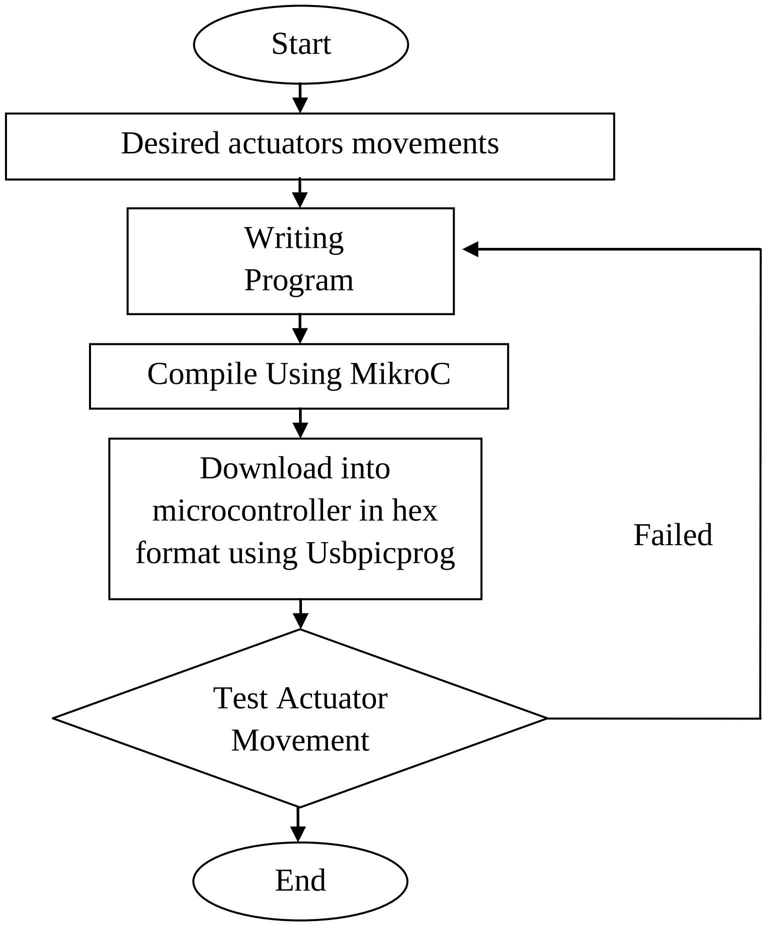

Figure 3.15 : Flowchart of programming design

Two software and a hardware are used for the programming part. MikroC compiler is used to create a program and compile the C code to the hex code form. In order to execute the hex code, software called Usbpicprog is used. The Usbpicprog will load the program into the microcontroller by using a USB PIC hardware programmer.

3.5.1 Mikro-C Pro

MikroC is a tool for PIC microcontrollers developed by mikroElektronika. It is designed to provide the programmer with the easiest possible solution for developing applications for embedded systems, without compromising performance or control. It will change the C code file to hex code file type.

To load the hex file produced by the MikroC into the microcontroller, Usbpicprog is used. This software will be used together with the programmer called Jazari USB PIC programmer for programming downloading process.

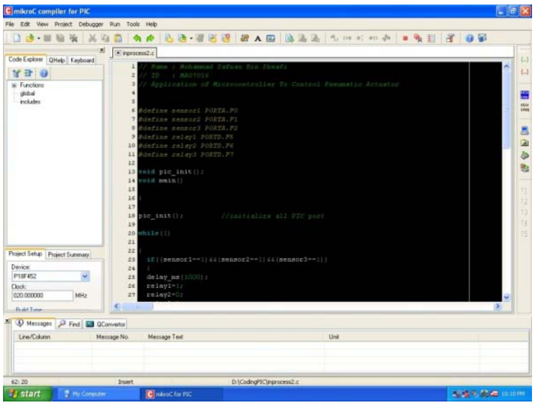

Figure 3.16 : Mikro-C Pro

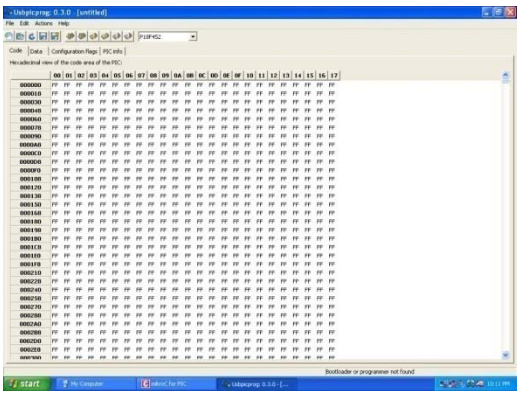

Figure 3.17 : Usbpicprog

3.5.2 Coding

```
#define sensor1 PORTA.F0
#define sensor2 PORTA.F1
#define sensor3 PORTA.F2
#define relay1 PORTD.F5
#define relay2 PORTD.F6
#define relay3 PORTD.F7

void pic_init();
void main()
{
pic_init();                 //initialize all PIC port
while(1)                    //forever loop
{
if((sensor1==1)&&(sensor2==1)&&(sensor3==1))
  {       delay_ms(1000);
          relay1=1;
          relay2=0;
          relay3=0;
          delay_ms(1000);
          relay1=1;
          relay2=1;
          relay3=0;
          delay_ms(1000);
 }  }
void pic_init(){
TRISA=0b10000111;
TRISD=0b00000000;

//End
```

Above coding shows the basic implementation of Boolean Flow Control combined with C operator. This coding example is to initiate the movement of the actuator at initial position. Complete coding will be provided in the appendix and more explanation on the coding will be explained details in the Chapter 4 of this thesis.

3.6 CONCLUSION OF CHAPTER

The methodology carried out was a development for this project. Without the methodology, the project will not run efficiently according to plan. The next chapter will focus on the results. The results that are going to be gained would be the outcome from the methodology where more discussions, calculations and photos detailed were presented to achieve all the project objectives.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The purpose of this chapter is to provide the test results and to analyze cost comparison between PIC and PLC. Discussions on programming steps and its chronology for further understanding are provided in details.

4.2 MOVEMENT OF ACTUATORS

The main objective of this project is to design and to construct circuit to integrate with a microcontroller in order to control pneumatic actuator. As for the project outcome, movement of actuator must follow flowchart shown in Figure 4.1 to ensure this main project objective is achieved. Movement of the actuators is recorded to show to panels as prove during presentation.

After all the actuators have move according to sequences, the measurement of thrust and pull force of the actuator can now be calculated. Pressure shown by the pressure gauge is rated at 2 bar. Standard bore diameter, D for the actuators used is 20mm and 8mm piston road diameter, d. Hence, the measurement of thrust and pull force are :

$$\text{Thrust} = F = \frac{\pi}{4} D^2 \frac{P}{10} \text{ N}$$

$$= \frac{\pi}{4} 20^2 \frac{2}{10} \text{ N}$$

$$= 62.83 \text{ N}$$

$$\text{Pull Force} \quad = \ F \quad = \frac{\pi\left(D^2\text{-}d^2\right)P}{40}$$

$$= \frac{\pi(20^2\text{-}8^2)2}{40}$$

$$= \frac{\pi(20^2\text{-}8^2)2}{40}$$

= 52.78 N

Calculation above shows that thrust force is greater than pull force. This force differences might be cause due to annular area of the piston that lead to pressure drop. Another rationale explanation is the pressure supply does not make allowance for the loss due to friction or air leakage. Therefore, to provide greater force, the bore size of the cylinder must be large enough to provide force to move the actuator after the pressure drop.

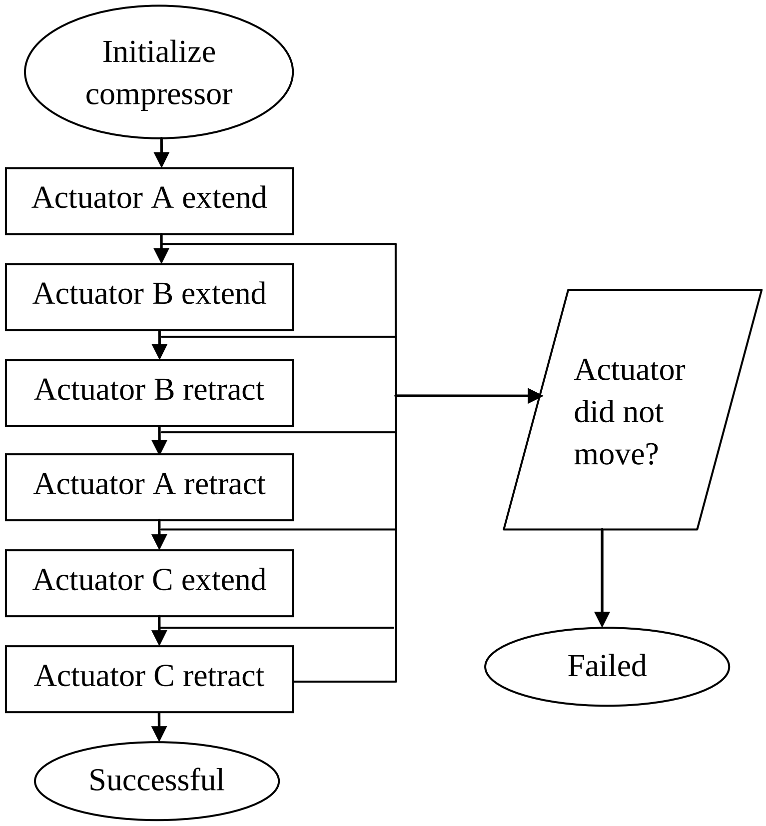

Figure 4.1 : Actuator movement flowchart

4.3 PNEUMATIC SYSTEM AND CIRCUIT INTEGRATION

With the aim to program the PIC hence to execute the program in order to move the mechanical components, complete circuit board must be created.

The first stage of development is to create the input circuit that consist of sensor wire, transistors, and resistors connected on a bread board. After that, output circuit is created for switching voltage purposes from 5V to 24V. Next, all the input, output and controller circuits part is connected together to produce the complete circuit board.

The complete circuit board is attached on a platform to be linked with the mechanical components. The figures of 4.2, 4.3, and 4.4 show the final result of pneumatic system attached with complete circuit board structure in various view respectively.

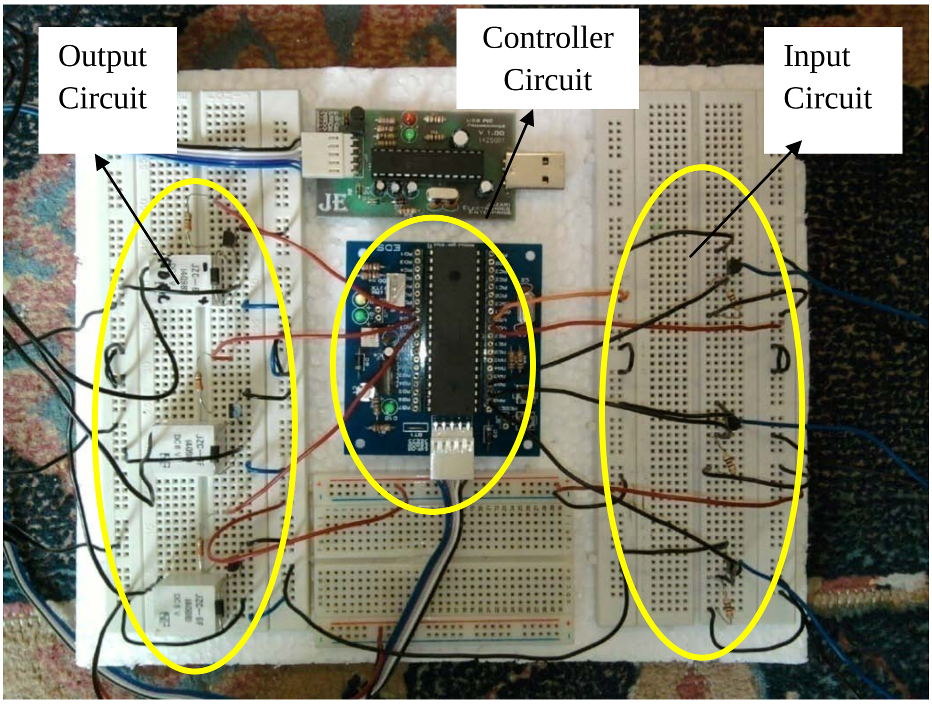

Figure 4.2 : Complete circuit board

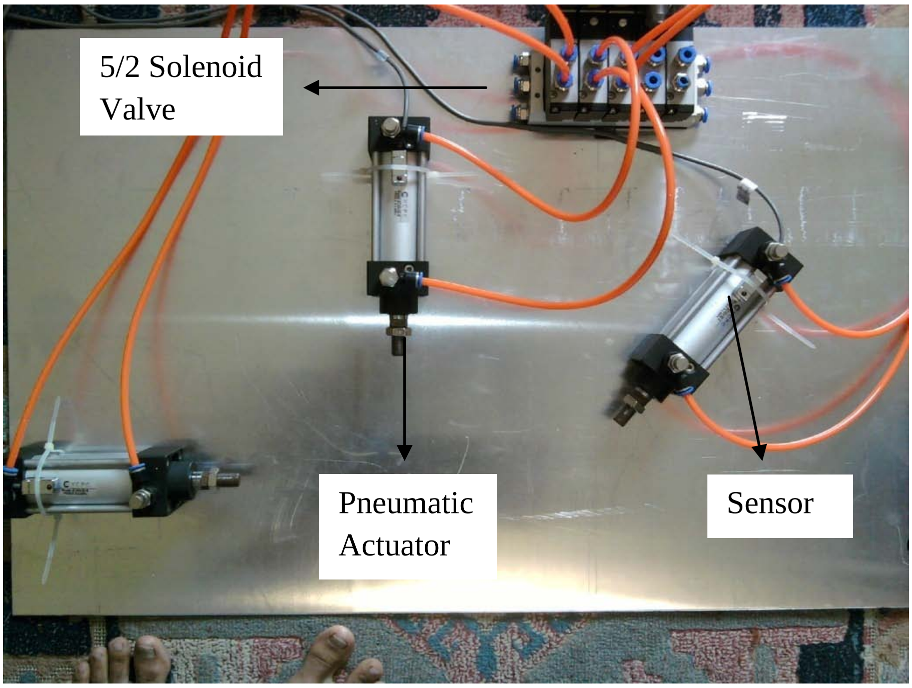

Figure 4.3 : Pneumatic system

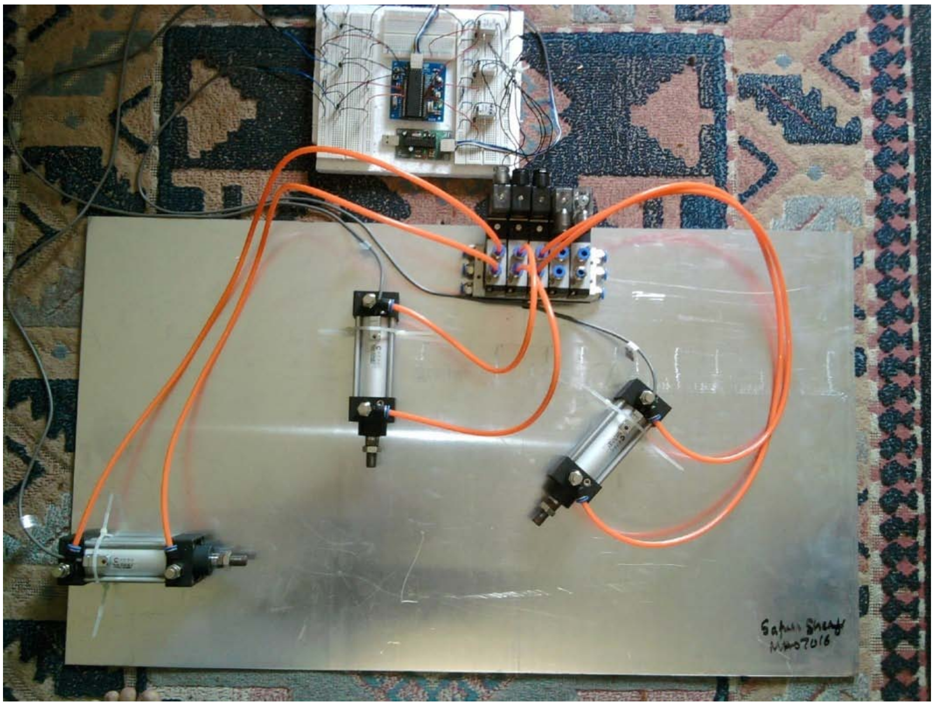

Figure 4.4 : Complete application circuit

4.4 COST ANALYSIS

Costs have large impact on profitability. It is possible to finish automating a process and eventually discover that there is no economic advantage in doing so. Therefore, calculation of PIC cost to be compared with existed programmable logic controller, PLC is crucial to see whether the PIC controller is cost-effective or not. For this purpose, Break-even Analysis is used to indicate total profit difference between these two types of controllers.

Reasonable conditions below need to be followed as for analysis to be fair and square:

i. Both controllers must have same number of I/O.
ii. One system, one controller.
iii. Same pneumatic system design and produce similar output.
iv. Variable cost refers to total cost of controller's components involved for that particular controller to run the system.
v. Assume number of volume produced is 20 units.
vi. Mark up price is 30% from the variable cost per unit. Therefore, price per unit, *p* shall be 130% from the variable cost per unit.
vii. The highest price per unit, *p* among these two controllers will be selected as the sale price.

4.4.1 PLC's Cost

Fixed cost, c_f	=	RM0
Volume, v	=	20
Variable cost per unit, c_v	=	RM100
Price per unit, p	=	RM100 x 1.30
	=	RM130
Total cost, TC	=	$c_f + vc_v$
	=	RM0 + [(20)(RM100)]
	=	RM2000
Total revenue, TR	=	vp
	=	[(20)(RM130)]
	=	RM2600
Profit, Z	=	TR - TC
	=	RM2600 – RM2000
	=	RM600

4.4.2 PIC's Cost

Fixed cost, c_f	=	Programmable USB
	=	RM140
Volume, v	=	20
Variable cost per unit, c_v	=	PIC chip + Electrical Components + Relays
	=	RM25+RM8+RM12
	=	RM45
Price per unit, p	=	RM45 x 1.30
	=	RM58.50

*Price per unit for PLC is higher which is RM130. For that reason, RM130 will be selected as price per unit, *p* for PIC.

Total cost, TC	=	$c_f + vc_v$
	=	RM140 + [(20)(RM45)]
	=	RM1040
Total revenue, TR	=	vp
	=	[(20)(RM130)]
	=	RM2600
Profit, Z	=	TR - TC
	=	RM2600 – RM1040
	=	RM1560

4.4.3 Cost Discussion

From both calculations showed, significant cost and profit difference can be seen. Total profit on behalf of PIC is 61.54% higher than profit from PLC when it is sell at the same price per unit, p .

$$\frac{(1560-600)}{1560} \times 100\% = 61.54\%$$

To see at which number of PIC need to be sold in order to gain profit more than PLC, a graph of variable cost against number of units must be plotted for both type of controllers. Before that, cost for each unit increment shall be determined.

PLC:

Starting cost, c_s	=	Fixed cost, c_f + Variable cost per unit, c_v
	=	0 + RM100
	=	RM100

Total next unit cost	=	Starting cost, c_s + Variable cost per unit, c_v
	=	RM100 + RM100
	=	RM200

PIC:

Starting cost, c_s	=	Fixed cost, c_f + Variable cost per unit, c_v
	=	RM140+ RM45
	=	RM185

Total next unit cost	=	Starting cost, c_s + Variable cost per unit, c_v
	=	RM185 + RM45
	=	RM230

Table 4.1 : Total unit cost for PLC and PIC on each unit

Unit	PLC Cost (RM)	PIC Cost (RM)
1	100	185
2	200	230
3	300	275
4	400	320
5	500	365
6	600	410
7	700	455
8	800	500
9	900	545
10	1000	590

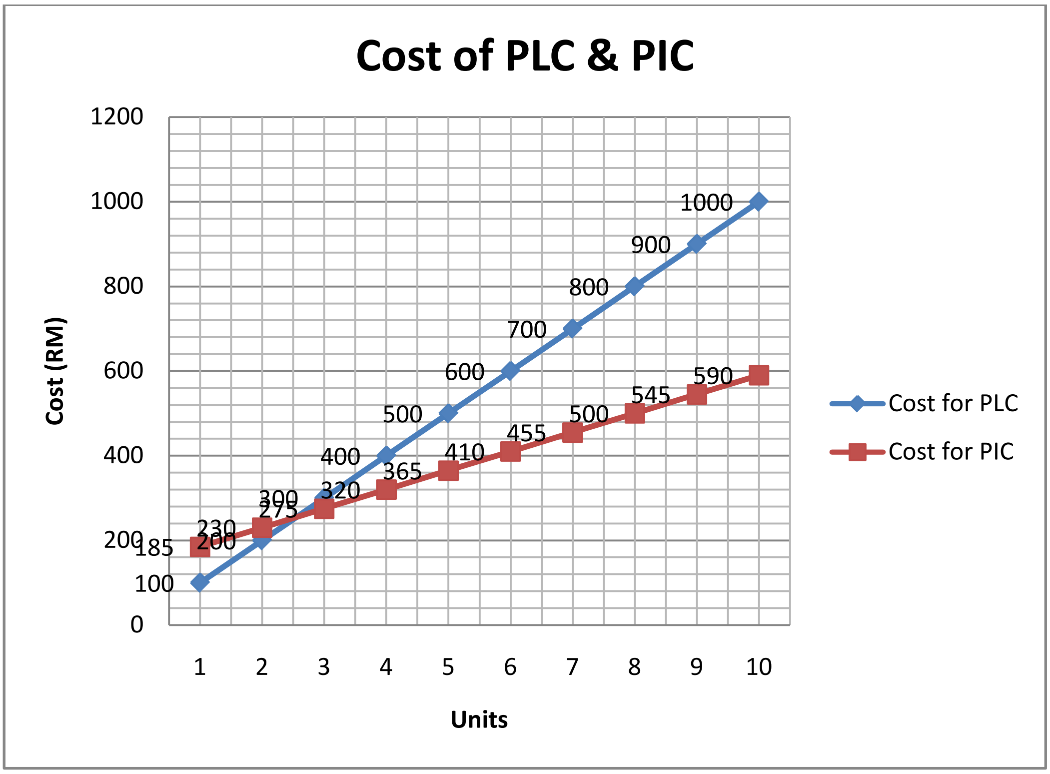

Figure 4.5 : Cost of PLC and PIC

From the graph plotted in Figure 4.5, it shows that PIC would start to gain profit if the number of units sold is more than 3 units of PLC. Starting cost for PIC is higher compare to PLC at first since to program a PIC, a programmable USB is required.

Though the starting price for PIC is higher at first, the graph magnificently shows that total cost for PIC is less compare to PLC for almost half of the total cost of PLC.

All the analysis shown in this subchapter proved that cost consumption for PIC is lower compare to PLC based on the reasonable conditions that has been subscribed.

4.5 PROGRAM STEPS

In this subchapter, explanation and discussion of microcontroller PIC Mikro-C programming will be discussed. Step by step explanation from the early stage of programming until it is send to microcontroller will be provided.

Step 1 :

Movement sequences of actuators involved are defined.

A+ B+ B- A- C+ C-

Step 2 :

Pneumatic circuit need to be draw to identify magnetic sensor position since only one sensor is used for each actuator.

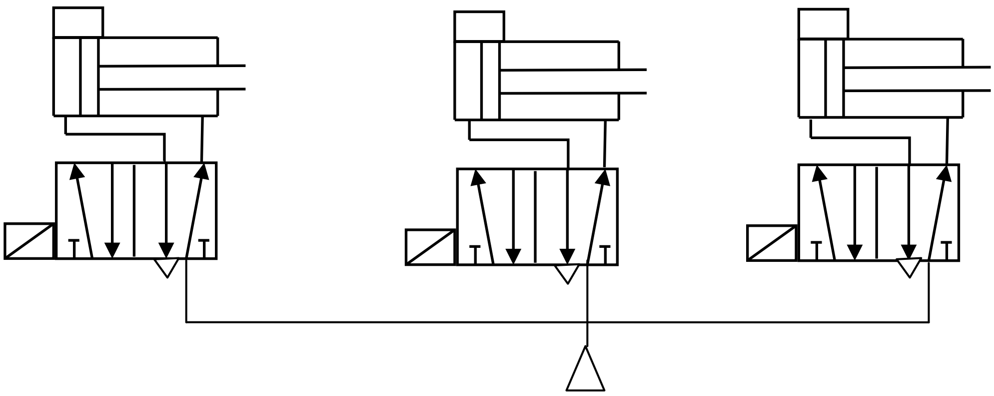

Figure 4.6 : Pneumatic Circuit

Based on pneumatic circuit above, sensor is located at initial position of each actuator. At this position, sensor is switched on since the sensor in contact with the bore of the cylinder.

Step 3:

Port of microcontroller that wants to be used is selected. For this, port RA1,RA2, RA3 are selected as input port while port RD5, RD6, RD7 are selected as output port.

Table 4.2 : Selected Microcontroller Port

Port	Pin	Function
PORT A	RA0	Sense output from magnetic sensor cylinder A
	RA1	Sense output from magnetic sensor cylinder B
	RA2	Sense output from magnetic sensor cylinder C
PORT D	RD5	Send voltage to valve to actuate cylinder A
	RD6	Send voltage to valve to actuate cylinder B
	RD7	Send voltage to valve to actuate cylinder C

Step 4:

A table based on microcontroller input logic and microcontroller output logic is draw. For microcontroller input logic, logic ‘1’ means sensor is switch on and logic ‘0’ means sensor is switch off.

As for microcontroller output logic, logic ‘1’ means microcontroller provides current to the relay to run solenoid valve while logic ‘0’ means no current provided by the microcontroller to the relay to switch on solenoid valve.

Table 4.3 : Microcontroller Input and Output Table

Actuator movement	RA0	INPUT LOGIC RA1	RA2	RD5	OUTPUT LOGIC RD6	RD7
A+	1	1	1	1	0	0
B+	0	1	1	1	1	0
B-	0	0	1	1	0	0
A-	0	1	1	0	0	0
C+	1	1	1	0	0	1
C-	1	1	0	0	0	0

From table 4.2, it shows that, to perform A+, RD5 will change its logic from logic ‘0’ to logic ‘1’. Also, after each movement of actuator, value for logic sensor is changed according to new position performed. For instance, after A+ is being performed, sensor input logic RA0 is changed from logic ‘1’ to logic ‘0’ on column B+.

Step 5:

Actuators are divided into groups. There cannot be two same actuators in the same group.

Table 4.4 : Actuators Divided Into Groups

Actuator movement	RA0	INPUT LOGIC RA1	RA2	RD5	OUTPUT LOGIC RD6	RD7
A+	1	1	1	1	0	0
B+	0	1	1	1	1	0
B-	0	0	1	1	0	0
A-	0	1	1	0	0	0
C+	1	1	1	0	0	1
C-	1	1	0	0	0	0

Group 1 : A+, B+

Group 2: B-, A-, C+

Group 3: C-

Step 6 :

For the first sequence for each group, their input logic will be selected as statement block in if-else-if structure. In that if-else-if block, all output logic for each movement of actuators in that particular group will be executed. Delay 1 second is added after each sequence to differentiate each sequence performed.

Group 1 : A+, B+

```
If ((RA0= =1) && (RA1= =1) && (RA2 = =1))      // Input Logic A+
{
        Delay_ms(1000);
        RD5 =1; RD6 =0; RD7=0;          // Output Logic A+
        Delay_ms (1000);
        RD5 =1; RD6 =1; RD7=0;          // Output Logic B+
        Delay_ms(1000);
}
```

Group 2 : B-, A-, C+

```
Else if ((RA0= =0) && (RA1= =0) && (RA2 = =1))      // Input Logic B-
{
        Delay_ms(1000);
        RD5 =1; RD6 =0; RD7=0;          // Output Logic B-
        Delay_ms (1000);
        RD5 =0; RD6 =0; RD7=0;          // Output Logic A-
        Delay_ms(1000);
        RD5 =0; RD6 =0; RD7=1;          // Output Logic C+
        Delay_ms(1000);
}
```

Group 3 : C-

```
Else if ((RA0= =1) && (RA1= =1) && (RA2 = =0))          // Input Logic C-
{
        Delay_ms(1000);
        RD5 =1; RD6 =0; RD7=0;              // Output Logic C-
}
```

<u>Step 7 :</u>

Complete programming in MikroC Pro is written.

```
#define     sensor1     PORTA.F0        //RA0
#define     sensor2     PORTA.F1        //RA1
#define     sensor3     PORTA.F2        //RA2
#define      relay1     PORTD.F5        //RD5
#define      relay2     PORTD.F6        //RD6
#define     relay3      PORTD.F7        //RD7

void pic_init();                        // create void for PIC port initialization
void main()
{
pic_init();                             //initialize all PIC port
while(1)                                //forever loop
{

        if((sensor1==1)&&(sensor2==1)&&(sensor3==1))  // Input Logic A+
        {
        delay_ms(1000);
        relay1=1; relay2=0; relay3=0;                 // Output Logic A+
        delay_ms(1000);
        relay1=1; relay2=1; relay3=0;                 // Output Logic B+
        delay_ms(1000);
        }
```

```
        else if ((sensor1==0)&&(sensor2==0)&&(sensor3==1))      // Input Logic B-
        {
        delay_ms(1000);
        relay1=1; relay2=0; relay3=0;                          // Output Logic B-
        delay_ms(1000);
         relay1=0; relay2=0; relay3=0;                         // Output Logic A-
         delay_ms(1000);
        relay1=0; relay2=0; relay3=1;                          // Output Logic C+
        delay_ms(1000);
  }

        else if ((sensor1==1)&&(sensor2==1)&&(sensor3==0))      //Input Logic C-
         {
         delay_ms(1000);
         relay1=0; relay2=0; relay3=0;                         //Output Logic C-
        }
}
}
void pic_init()
{
TRISA=0b10000111;              //Declare RA0,RA1 and RA2 as input
TRISB=0b000000000;
TRISC=0b00000000;
TRISD=0b00000000;              //Declare all port D as output
TRISE=0b00000000;
ADCON1=0b00000110;             //Configures the functions of the port pins
PORTA=0b10000111;
PORTB=0b000000000;
PORTC=0b00000000;
PORTD=0b00000000;
PORTE=0b00000000;
}
```

4.6 CONCLUSION OF CHAPTER

By the end of this chapter, the microcontroller had performed its task successfully by controlling the sequences of the actuators. Result of the test shows that microcontroller can be implemented to control pneumatic system at a low cost. With several imperfection of the microcontroller, the refinement was then suggested to improve its performances. Overall conclusion will further explained in the next chapter. The future work with brief explanation will be mentioned in the next chapter.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter will conclude the development of this project. The outcome of the project will be related to the scope and objective of the project. From that, the project will be determined whether its objective is achieved or not. This chapter was outline to begin with conclusion followed by recommendations for future work.

5.2 CONCLUSION

The conclusion of the project can be declared as successful. The testing was done in a believed to be precisely and follow the application design. Furthermore, there is no bias in producing the result.

The entire objective was successfully achieved. The project had developed a microcontroller to control pneumatic actuator which implements the combination of mechanical and electrical components. Real time test prove that complete circuit produced can perform basic movement of extend and retract of pneumatic actuator based on the program that has been downloaded to the microcontroller.

Cost analysis that has been done in Chapter 4 proved that PIC consume low cost production compare to existed PLC controller. The outcomes of this development are ready to be further developed by the automation industry. In simple phrase, the new microcontroller system, PIC could be realized and use for pneumatic system in any automation industry at low cost compare to PLC.

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APPENDIX A

GANTT CHART / PROJECT SCHEDULE FYP 1

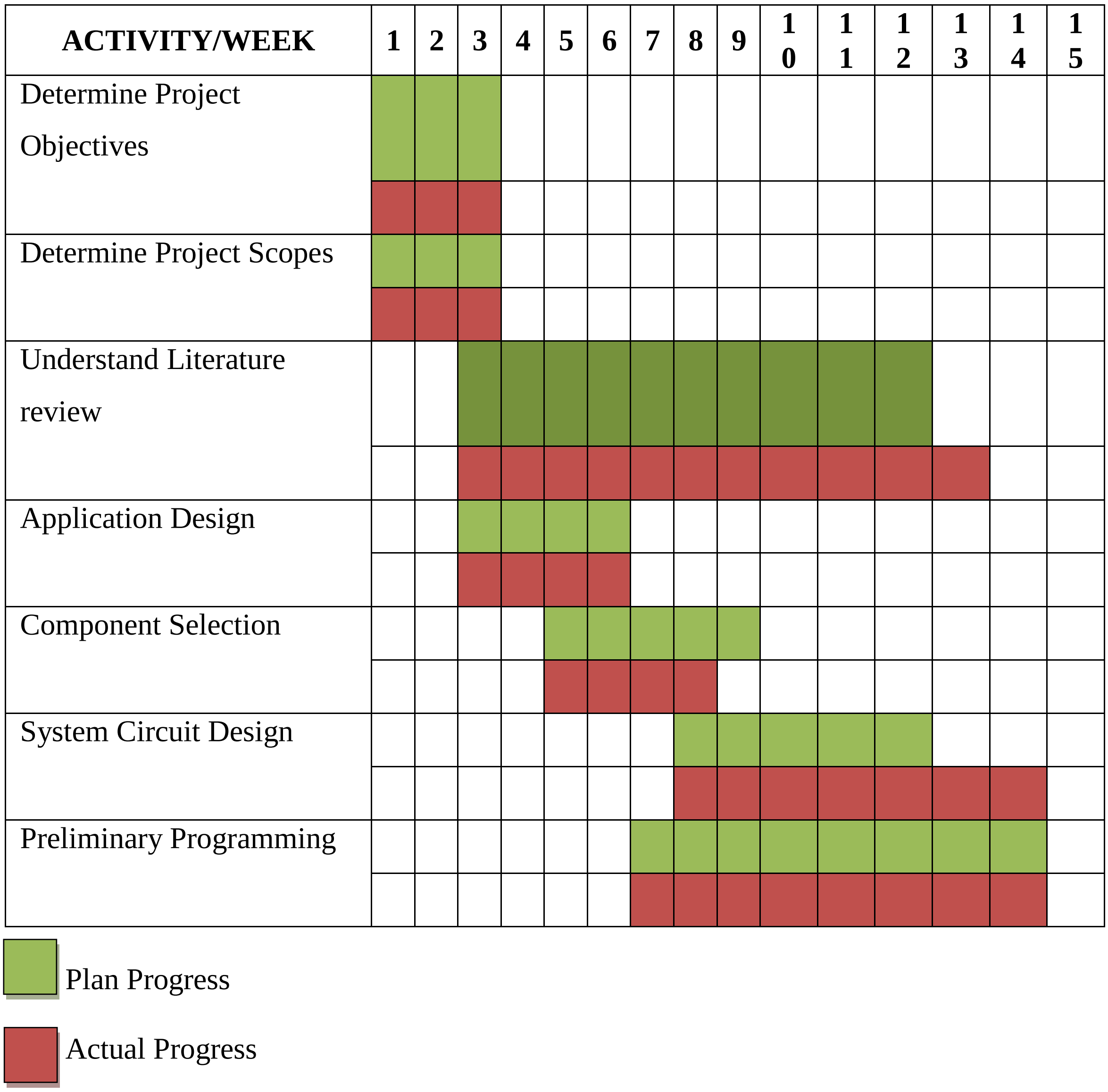


Figure 6.1 : FYP 1 project planning

APPENDIX B

GANTT CHART / PROJECT SCHEDULE FYP 2

ACTIVITY/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Full Programming	Plan	Plan	Plan	Plan	Plan	Plan	Plan	Plan							
	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual							
Build Electronic Board Circuit			Plan	Plan	Plan	Plan	Plan	Plan	Plan	Plan					
			Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual		
Build Pneumatic System			Plan	Plan	Plan	Plan	Plan	Plan							
			Actual	Actual	Actual	Actual	Actual								
Combine, Test and Run Both									Plan	Plan	Plan	Plan			
Electronic and Pneumatic system								Actual	Actual	Actual	Actual	Actual	Actual		
Prepare Full Report											Plan	Plan	Plan	Plan	Plan
											Actual	Actual	Actual	Actual	Actual
Compile														Plan	Plan
															Actual

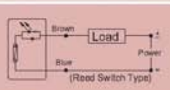
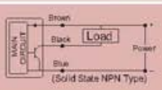
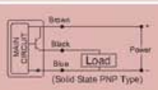
Plan Progress   Actual Progress

Figure 6.2 : FYP 2 project planning

APPENDIX C

Magnetic Sensor

Magnetic Sensor Specification

CHARACTERISTIC \ TYPE	Reed Switch	NPN Type	PNP Type
Switching Logic	SPST Normally Open	Solid State Output,Normally Open	
Sensor Type	Reed Switch	NPN Current Sourcing	PNP Current Sourcing
Operating Voltage -Note 1.	JRTM, JRT-02 5 to 120V DC/AC JRT-03, 34 5 to 240V DC/AC	5 to 28V DC	
Switching Current	100mA max.	200mA max.	
Switching Rating	5 W max.	20 W max.	
Voltage Drop	2.5V max.@40mA to 100mA DC	1.5 V max.@ 200mA DC(Resistive Load)	
Leakage Current	-	0.01 mA max.	
Current Consumtion	-----	15 to 20 mA max.	16 to 18 mA max.
Indicator	Red LED	Red LED	Green LED
Cable	2C,Oil Resisdent PVC JRTM PU	3C,Oil Resisdent PVC	
Max. Switching Frequency	200 Hz	1000 Hz	
Temperature Range	-10 to 70		
Shock -Note 2.	30G	50G	
Vibration -Note 3.	9G		
Insulation Resistance	100MΩ (Measured by 500V DC Mega between Lead to Case)		
Dielectric Strength	1500V AC rms for 1 minute or 1800V DC rms for 1second(Lead to Case)		
Enclosure Classification	IP 67 (NEMA 6)		
Protection Circuit	None	Power Source Reverse Polarrity;Surge Suppression	
CE Certificate No.	No. E8 04 07 53334 001	No. E8 04 07 53334 003	No. E8 04 07 53334 002
3C Certificate No.	No.:2004010305127433	-	
CNEx Certificate No.	CNEx05. 1366X(ExnCIICT6)	CNEx05. 0842 (ExiaIIBT6)	
Connect Diagram	 Reed Switch	 NPN Type	 PNP Type

▶ Note

1. The max. operating voltage of T-□□R-QD8 is 60V AC/DC (Based on IEC61076-2-101).
2. Sin Wave / X` Y` Z 3 Directions /3 Times Each Direction / 11mS Each Time.
3. Double Amplitude 1.5mm / 10Hz~55Hz to10Hz(Sweep 1min) / X` Y` Z 3 Directions / 1Hour Each Time.
4. Measuring standard target: 15.5 x 8 x 5t(Anisotropic Rubber Magnet).
5. We reserve the right to make changes without notice.

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APPENDIX D

JAZARI 2U
[JM0526740-U]

To	En. Mohd Fadzil Faisae bin Ab. Rashid Fakulti Kejuruteraan Mekanikal Universiti Malaysia Pahang Lebuhraya Tun Razak 26300 Gambang, Kuantan, Pahang Darul Makmur	**Quotation No** **Date**	J2UQ-120902 10 Dec 2009

NO	ITEM	DESCRIPTION	QUANTITY	UNIT PRICE (RM)	AMOUNT (RM)
1	PIC – Win XP	PIC set with USB PIC Programmer for Win XP	3	140.00	420.00
2	PIC - Vista	PIC set with USB PIC Programmer for Vista	2	140.00	280.00
3	Resistor 100ohm	0.25W resistor 100ohm	30	0.05	1.50
4	Resistor 10Kohm	0.25W resistor 10Kohm	30	0.05	1.50
5	Capacitor 4.7uF	Electrolyte Capacitor	10	0.20	2.00
6	Capacitor 33pF	Ceramic Capacitor	20	0.20	4.00
7	Capacitor 0.1uF	Ceramic Capacitor	10	0.20	2.00
8	Push Button	White push button	20	0.20	4.00
9	Voltage Regulator	7805 positive regulator	10	1.00	10.00
10	Crystal	20Mhz crystal	10	2.00	20.00
11	Battery	9V battery	10	5.00	50.00

Total	**RM**	795.00
Discount		0.00
Net	**RM**	795.00

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5.3 RECOMMENDATIONS FOR FUTURE WORK

Towards perfecting the project, recommendations on future work have been listed as below:

i. The bread board should be change with the normal PCB board with the aim of reducing the size of the complete board circuit.
ii. Create external casing to cover up the microcontroller from outer disturbance. The casing should be light in weight and it should allow air to flow in and out to avoid the controller from heating up.
iii. Manual start and stop push button for the microcontroller itself should be added instead of using the on and off button from the voltage supply. This is for the safety purposes.

UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "*Application of Microcontroller to Control Pneumatic Actuator*" is written by *Mohammad Safuan bin Sheafi*. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering.

Dayangku Noorfazidah Awang Shri ....

Examiner Signature

APPLICATION OF MICROCONTROLLER TO CONTROL PNEUMATIC ACTUATOR

MOHAMMAD SAFUAN BIN SHEAFI

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature	....
Name of Supervisor:	FIRDAUS BIN HASSAN
Position:	LECTURER OF MECHANICAL ENGINEERING
Date:	6 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature ....

Name: MOHAMMAD SAFUAN BIN SHEAFI

ID Number: MA07016

Date: 6 DECEMBER 2010

Dedicated, truthfully for supports,
encouragements and always be there during hard times,
my beloved family.

ACKNOWLEDGEMENTS

Alhamdulillah, praise to be Allah for His blessings and giving me the strength along the tough journey of completing my Final Year Project as well as this thesis writing, for without it, I would not have been able to come this far.

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My outmost thanks also go to my family who has given me support throughout my academic years especially my parents. Many special thanks go to my fellow friends for the excellent understanding, co-operation, inspiration, and supports during my study here.

Last but not least, thanks to individuals that has contributed either directly or indirectly to make this thesis project. May Allah bless all of you. Amin.

ABSTRACT

Pneumatics Technology is capable of utilizing the compressed air to perform work and to organize functions. Pneumatic actuator, which is one of the elements in pneumatic system, has been recognized for its flexibility to do various types of work and its capability in diversity of applications. Commonly known controller to control the pneumatic system movements is Programmable Logic Controller (PLC). However, the cost of PLC is expensive for small automation system and it size basis can be consider large as a controller. To overcome this problem, there is a new thought to use Programmable Interface Controller (PIC) which is smaller and cheaper to replace PLC. Main purpose of this project is to make the idea alive. This project will mainly concerned on controlling the sequence of the three linear double-acting cylinder actuator movements by using microcontroller PIC 18F452 coupled with pneumatic solenoid valve. This microcontroller is used for controlling predefined sequences of opening and closing of solenoid valves that will activate the actuator. A program in MikroC PRO is written and developed to communicate with the microcontroller as to move the actuator according to plan sequences. For purpose of voltage regulation, a single-pole double throw (SPDT) relays are used as “OUTPUT” signal from the sensor for the microcontroller. The “OUTPUT RELAY” is of the 6V SPDT powered from the switching output voltage 5V dc of the microcontroller to convey the 24V dc to control the solenoid pneumatic valve. The application that is going to be developed must be in a low cost and a small scale basis. Subsequently, experimental simulation tests will be conducted to evaluate the response and accuracy behaviour of the microcontroller interacting with the solenoid valves.

ABSTRAK

Teknologi Pneumatik mampu memanfaatkan tekanan untuk melakukan pekerjaan dan untuk menetapkan fungsi. Pneumatik aktuator, yang merupakan salah satu unsur dalam sistem pneumatik, telah diakui kerana fleksibilitinya untuk melakukan pelbagai jenis pekerjaan dan kemampuan dalam kepelbagaian aplikasi. Umumnya untuk mengendalikan gerakan sistem pneumatik, sistem kawalan yang digunakan adalah Program Kawalan Logic (PLC). Namun, kos untuk sistem ini adalah mahal untuk sistem automasi kecil dan saiznya boleh dianggap besar sebagai controller. Untuk mengatasi masalah ini, ada pemikiran baru untuk menggunakan Program Kawalan Interface (PIC) yang lebih kecil dan lebih murah untuk menggantikan PLC. Tujuan utama projek ini dijalankan adalah untuk membuat idea itu hidup. Projek ini mengutamakan pengendalian urutan tiga gerakan linear silinder berkembar dengan menggunakan mikrokontroller, PIC18F452 digabungkan dengan injap pneumatik solenoid. Mikrokontroler ini digunakan untuk mengawal urutan pembukaan dan penutupan injap solenoid yang akan mengaktifkan aktuator. Sebuah program di MikroC PRO ditulis dan dibangunkan untuk berkomunikasi dengan mikrokontroler untuk menggerakkan aktuator sesuai dengan urutan rencana. Untuk tujuan regulasi voltan, ganda kutub tunggal membuang (SPDT) relay digunakan sebagai isyarat "OUTPUT" dari sensor untuk mikrokontroler. Simbol "OUTPUT RELAY" adalah dari SPDT 6V kuasa voltan keluar dari suis 5V dc dari mikrokontroler untuk menyampaikan dc 24V untuk mengawal injap pneumatik solenoid. Aplikasi yang akan dibangunkan harus dengan kos yang rendah dan dasar skala kecil. Selanjutnya, ujian simulasi eksperimen akan dilakukan untuk menilai perilaku respon dan ketepatan dari mikrokontroler berinteraksi dengan injap solenoid.

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LIST OF SYMBOLS

°C	Degrees Celcius
F	Force
I_L	Load Current
V_S	Voltage Supply
R_B	Base Resistor
h_{FE}	Transistor Current Gain
V_{CC}	Microcontroller 5v Voltage
c_f	Fixed Cost
v	Volume (Number Of Units Produced)
c_v	Variable Cost Per Unit
p	Price Per Unit
A	Ampere
Ω	Ohm
V	Voltage
mm	Milimeter
μ	Micro

LIST OF ABBREVIATIONS

PLC	Programmable Logic Controller
PIC	Programmable Interface Controller
DC	Direct Control
dc	Direct Current
SPST	Single Pole Single Throw
SPDT	Single Pole Double Throw
PWM	Pulse Width Modulation
I/O	Inputs / Outputs
AC	Actuating Current
DC	Direct Current
V	Voltage
F	Farad
CPU	Central Processing Unit
RAM	Random Access Memory
ROM	Read Only Memory
GND	Ground
C	Computer