

PICKBOT

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*Specially dedicated to  
To my beloved parents, sisters and brothers*

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## **ABSTRACT**

The final year project is to design and developed hardware pickbot which can assign a task to pick and place an object. As we know, commonly human can't work efficiently in along period without neglecting emotion and fatigue. In this project, Pickbot will help human to work with efficient and make a less mistake and also replace human to pick and place object in crucial corner. This pickbot project refers to arm robot that is controlled using microcontroller. In this project, an electrical actuator will be used which is servo motor. This actuator is suitable for this project because the angle movement of servo motor can be controlled. This project involved three main parts to be developed; which are hardware, circuit and software. The hardware parts are consists is the material that are used to build the robot and the design which is the suitable material for this pickbot. The circuit part consists of the microcontroller circuit, because the microcontroller is known as a brain of this robot. All the movement of the robot will be assigned by using microcontroller. The software part is to design the programming that will be used to assign an angle of movement for each servo motor to pick and place the object.

## ABSTRAK

Projek tahun akhir ini adalah bertujuan untuk reka cipta dan membina robot yang boleh melakukan tugas mengangkat dan meletak objek (pickbot). Seperti yang diketahui umum, manusia tidak dapat bekerja dengan efisien untuk satu jangka masa yang panjang tanpa menghiraukan emosi dan tenaga. Robot pickbot boleh menggantikan manusia untuk mengatasi masalah tersebut serta melakukan tugas mengangkat dan meletak objek di sudut yang sukar. Projek robot pickbot ini merujuk kepada robot lengan yang dikawal oleh pengawalmikro. Robot pickbot ini menggunakan servo motor sebagai penggerak robot. Pemilihan servo motor adalah kerana motor ini boleh mengawal pergerakan mengikut sudut darjah. Pembinaan projek ini terbahagi kepada 3 bahagian utama iaitu perkakasan, litar dan perisian. Pembinaan perkakasan adalah proses untuk membina badan robot pickbot iaitu proses pemilihan bahan dan reka bentuk yang sesuai. Pembinaan litar adalah proses pembinaan litar pengawalmikro yang berfungsi sebagai otak, ini kerana semua pergerakan servo motor dikawal oleh pengawalmikro. Pembinaan perisian adalah pembinaan aturcara untuk digunakan dalam mengawal pergerakan setiap servo motor membuat proses mengangkat dan meletak objek.



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**LIST OF SYMBOLS**

$h$	-	height
$F$	-	Force
$g$	-	Gravity = 9.81 m/s
$m$	-	Mass
$t$	-	Torque

## LIST OF ABBREVIATIONS

Pickbot	-	Pick and place robot
DC motor	-	Direct current motor
AC motor	-	Alternating current motor
RAM	-	Random-access memory
PBP	-	Picbasic Pro
PWM	-	Pulse width modulation



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## CHAPTER 1

### INTRODUCTION

#### 1.0 Introduction

The productivity and a quality product is the first element people in industry move forwards. The pressing need is to increased productivity and delivery of product of uniform quality, industry is turning more and more toward computer based automation. At this time, a special purpose machine designed to perform predetermined function in manufacturing process carries most automated tasks. Robot is one of an example of the technology computer based automation that produces by human.

A robot is a mechanical or virtual, artificial agent. A robot is usually an electro-mechanical system, which, by its appearance or movements, conveys a sense that it has intent or agency of its own. According to the Robot Institute of America (1979) a robot is define as ‘A reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks’ [1]. The word robot can refer to both physical robots

and virtual software agents, but the latter are often referred to as bots [2]. According to the Karel Capek the first person use term 'robot', the industrial robot was design to assist human being and not to replace them. There is so many type of robot; one of the types is industrial robot. Industrial robot is a programmable and manipulate designed to move materials, parts tools, or specialized devices through variable programmed motions for performance of a variety of tasks [3].

This project is build because commonly human cannot work efficiently in along period without neglecting emotion and fatigue. Human also have a limitation to execute picking and placing object in crucial corner. In this project, Pickbot will help human to work with efficient and make a less mistake also replace human to pick and place object in crucial corner.

## **1.1 Objectives**

The main of objectives of this project are to:

- i. Design a pickbot using microcontroller
- ii. Design the pickbot that able to pick and place square object

## 1.2 Scope of the Project

Generally, the scope of this pickbot project is to design a pickbot using the microcontroller. Figure 1 is about the block diagram of this pickbot project. Main part of this pickbot project is to build and design chassis robot using a suitable material. The microcontroller as brains in this project will be interfaced with the input and output hardware. Input hardware for this project is a switch and the output hardware is servomotor as actuators to drive a movement of the pickbot. A circuit design is required, this for electronics controlling device such as circuit for microcontroller, input, switching circuit and output, servo motor circuit. Software (programming) for microcontroller will be created to interface the hardware and the microcontroller. To complete the objective, pick and place square object, the hardware such circuit and pickbot chassis will be integrated with the software is required.

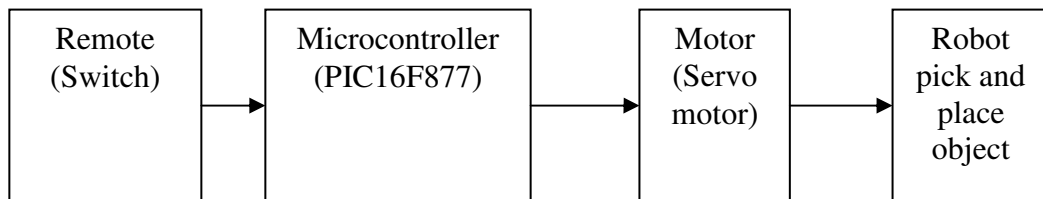


Figure 1.1: Block diagram of pickbot project



## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

To build this project successful, some studies and information gathering has been done. All of this information is very useful as a guide in doing this project. This information is fetching from many sources such as books, article, journal and internet sources. The studies and gathering information based on some major component and topic that related to the project that will be used in project such hardware and software.

#### **2.1 Pickbot and Industrial Robot**

Pickbot is one of the industrial robot that commonly use in industries. Pickbots growing in complexity and their use in industry is becoming more widespread. The main

use of industrial robots has been in the automation of mass production industries, where the same, definable tasks must be performed repeatedly in exactly the same fashion. Car production is the primary example for the employment of large and complex robots for producing goods. Industrial robots are used in that process for the painting, welding and assembly of the cars. Industrial robots are good for such tasks because the tasks can be accurately defined and must be performed the same every time, with little need for feedback to control the exact process being performed. Industrial robots can be manufactured in a wide range of sizes and so can handle more tasks requiring heavy lifting than a human could [4]. The figure 2.1 below shows the example of industrial robot used in factory.

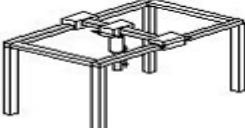
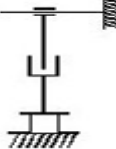

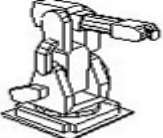
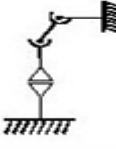

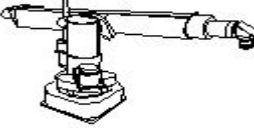
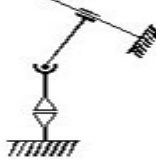



Figure 2.1: Industrial robot

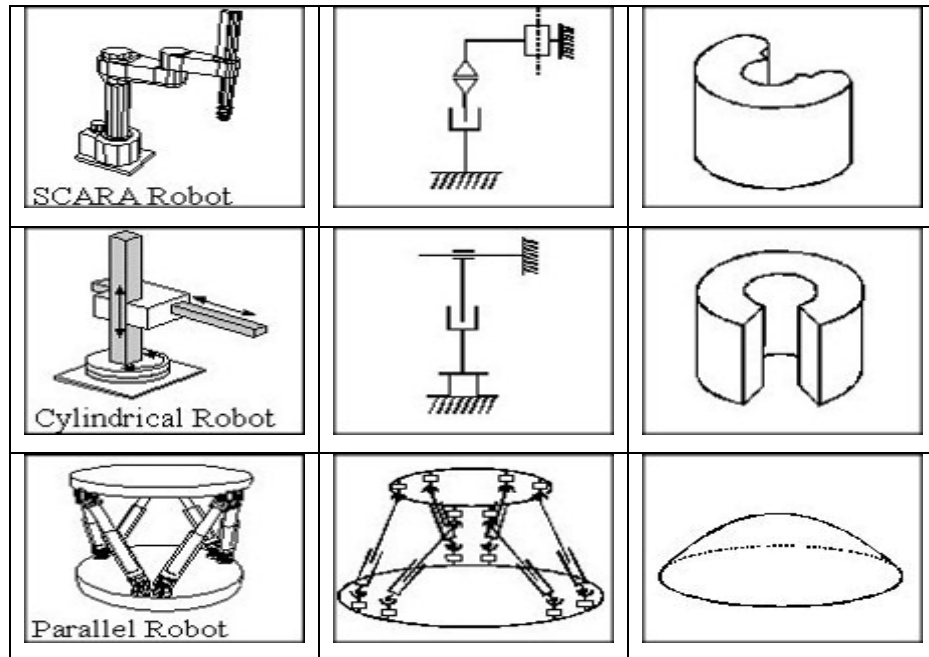
### 2.1.1 Type of Industrial Robot

There is 6 types of industrial robot that commonly use in industrial. Cartesian robot, cylindrical robot, spherical robot, scara robot, articulated robot and parallel. Table 1 shows the kinematics' structure and work place of the industrial robot. Cartesian Robot/Gantry Robot is a robot whose arm three prismatic joint, whose axes are coincident with a Cartesian coordinator. Cylindrical robot is a robot whose axes form cylindrical coordinator systems. Spherical robot is a robot whose axis forms a polar coordinator system. Scara Robot is a robot that has two parallel rotary joints to provide compliance in a plane. Articulated robot is a robot whose arm has at least three rotary joints. Parallel robot is robot whose arms have concurrent prismatic or rotary joints [5].

Table 2.1: Type of industrial robot

Robot	Kinematics Structure	Workplace
 Cartesian Robot		
 Articulated Robot		
 Spherical Robot		





## 2.2 Motor

An electrical motor is defined as a motor that converts electrical energy to a mechanical energy to do work. It allows electric power to be used to run machinery. A motor basically, connected to a source of electrical power develops a twisting effort, that usually rotates the shaft of the motor. When this shaft connected, belted, or geared to a machine, it drives the machine to do a work. There are two types an electrical motor: Direct Current motor (DC motor), Alternating Current Motor (AC motor) and Universal Motor (can operate AC and DC current) [6].

### 2.2.1 Advantages of Servo Motor

A servomechanism, or servo, is a device used to provide control of a desired operation through the use of feedback [7]. The servo family is further divided into AC and DC types. A servo motor can be either DC or AC, and is usually comprised of the drive section and the resolves/encoder. An AC servo had the advantage of being able to handle much higher current surges than a DC, as the DC has brushes, which are the limiting factor in this case. Servo motor is a motor used for motion control in robot, hard disc drives and another application. Generally, servo motor is design more like an alternator than a standard motor; most servos need special control circuitry to make them rotate electrically. Some can be use in reverse to generate alternating current. Figure 2.2 shows the servo motor model Hitec Hs-422.



Figure 2.2: Hitec Hs-422

The advantages using servo motor than stepper motor is much smoother in motion than a comparable stepper, and will have a much higher resolution for position control. Steppers, on the other hand, have economy as an advantage but the advantages using servo motor over stepper motor is high intermittent torque, high speeds, work well for velocity control, available in all sizes and work in quiet [8].

## 2.2.2 How does servo motor work

Servos are controlled by sending them a pulse of variable width. The control wire is used to send this pulse. The parameters for this pulse are that it has a minimum pulse, a maximum pulse, and a repetition rate. Given the rotation constraints of the servo, neutral is defined to be the position where the servo has exactly the same amount of potential rotation in the clockwise direction as it does in the counter clockwise direction. It is important to note that different servos will have different constraints on their rotation but they all have a neutral position, and that position is always around 1.5 milliseconds (ms)[9]. Figure 2.3 show the graphical view of servo motor positioning.

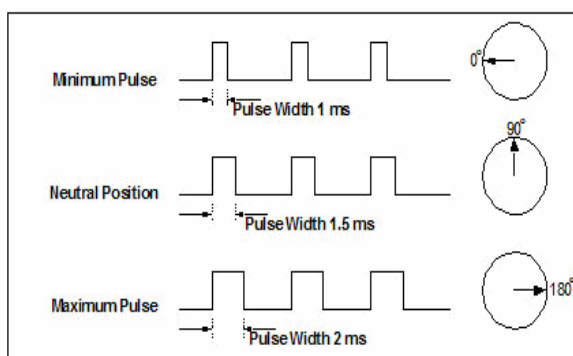


Figure 2.3: Graphic view of servo positioning

The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse width Modulation. The servo expects to see a pulse every 20 ms. The length of the pulse will determine how far the motor turns. For example, a 1.5 ms pulse will make the motor turn to the 90 degree position (neutral position).

When these servos are commanded to move they will move to the position and hold that position. If an external force pushes against the servo while the servo is

holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is the torque rating of the servo. Servos will not hold their position forever though; the position pulse must be repeated to instruct the servo to stay in position.

When a pulse is sent to a servo that is less than 1.5 ms the servo rotates to a position and holds its output shaft some number of degrees counterclockwise from the neutral point. When the pulse is wider than 1.5 ms the opposite occurs. The minimal width and the maximum width of pulse that will command the servo to turn to a valid position are functions of each servo. Different brands, and even different servos of the same brand, will have different maximum and minimums. Generally the minimum pulse will be about 1 ms wide and the maximum pulse will be 2 ms wide.

### **2.3 Microcontroller**

A microcontroller is an inexpensive single-chip computer. Single-chip means that the entire computer system lies within the confines of the integrated circuit. The microcontrollers existing on the encapsulated silver of silicon have features and similarities to our standard personal computers. Primarily, the microcontroller is capable of storing and running a program [9]. Microcontrollers are frequently used in automatically controlled products and devices, such as automobile engine control systems, office machines, appliances, power tools, and toys. By reducing the size, cost, and power consumption compared to a design using a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to electronically control many more processes.

### **2.3.1 Advantages Using Microcontroller over Microprocessor**

A microcontroller (MCU) is a computer-on-a-chip. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor. The only difference between a microcontroller and a microprocessor is that a microprocessor has three parts - ALU, Control Unit and registers (like memory), while the microcontroller has additional elements like ROM, RAM etc.

The advantage of using MCU is a microcontroller is an inexpensive single-chip computer. Single-chip means that the entire computer system lies within the confines of the integrated circuit. The microcontroller contains a central processing unit (CPU), random-access memory (RAM), read-only memory (ROM), electrical erasable programmable read-only memory (EEPROM), input/output (I/O) lines, serial and parallel ports, timer and other built-in peripherals, such as ADC (analog-digital-converter) and DAC (digital analog converters. The most common microcontroller use is PIC (Microchip), MC68HC16 (Motorola), etc.

### **2.3.2 Microcontroller PIC16F877 Features**

PIC16F877 is one of the Microchip technology company products [10]. This MCU is the most suitable for this project. Figure 2.4 shows the block diagram of PIC16F877 microcontroller, Figure 2.5 shows the specification pin of the microchip, PIC16F877. The features or specification that have in this MCU PIC16F877 is high performance RISC CPU and all cycle instruction except for program branches which is 2 cycle. Operating speed DC-20MHZ clock input. Data memory for EEPROM built in is 256 X 8 byte. The special features in this PIC16F877 is Oscillator selection, have 4 reset

way, Power-on Reset (POR) , Power-up Timer (PWRT), Oscillator Start-up Timer (OST) and Brown Out Reset (BOR). Other specialty is, this microcontroller have Interrupt, watchdog timer, Sleep, code protection and ID location [11].

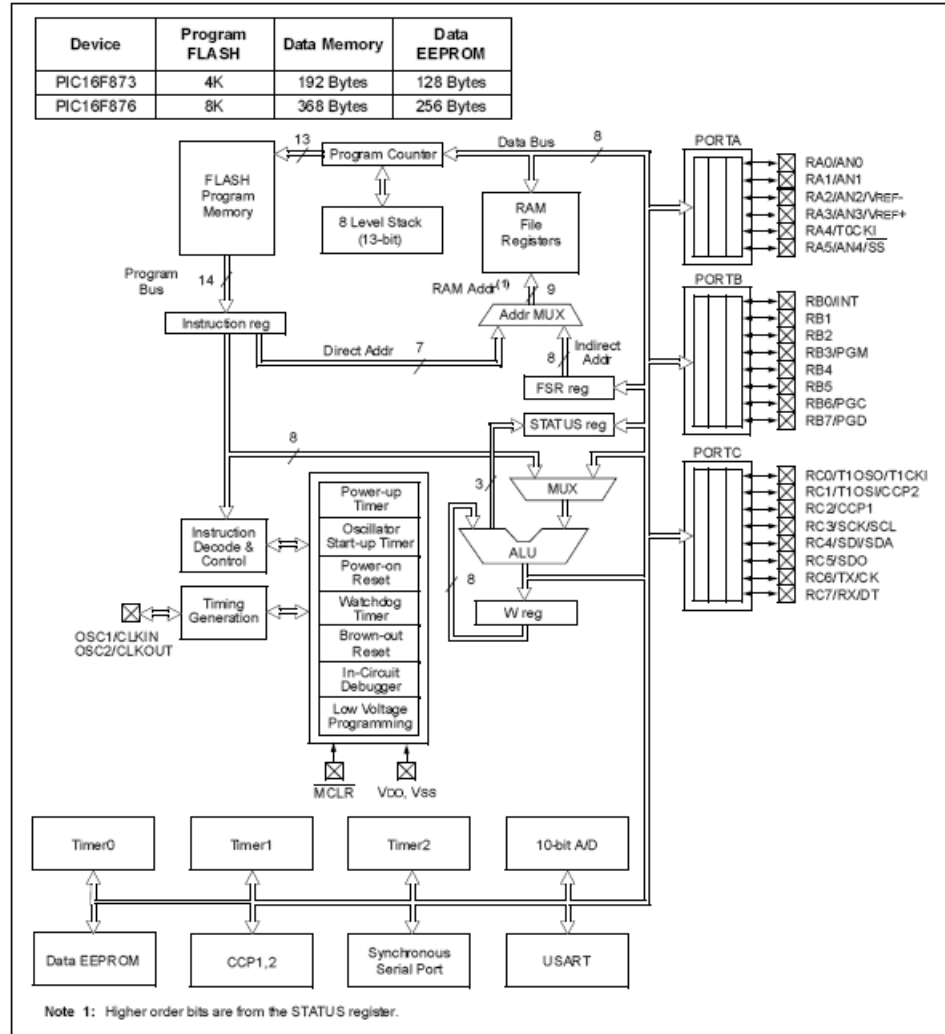


Figure 2.4: PIC16F877 block diagram

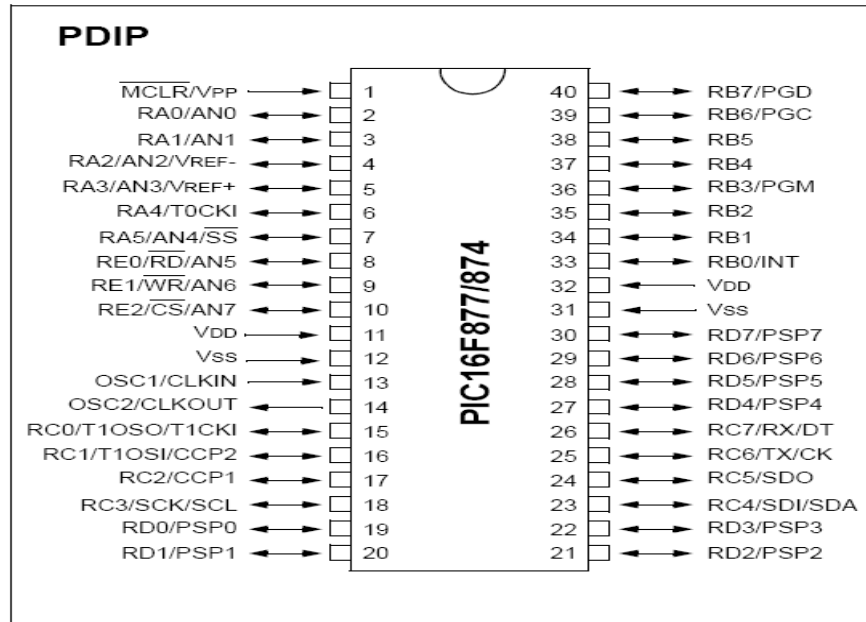


Figure 2.5: 40 pin PIC16F877

### 2.3.3 USB Programmer

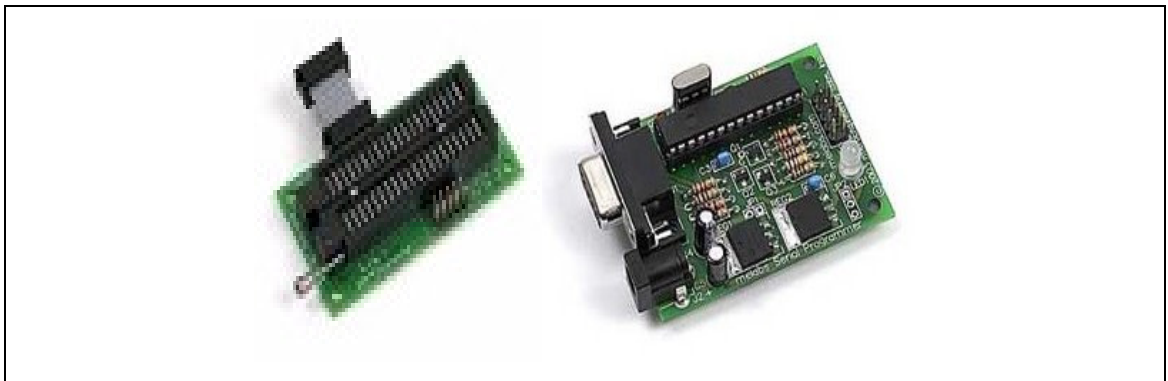


Figure 2.6: Melab U2 programmer

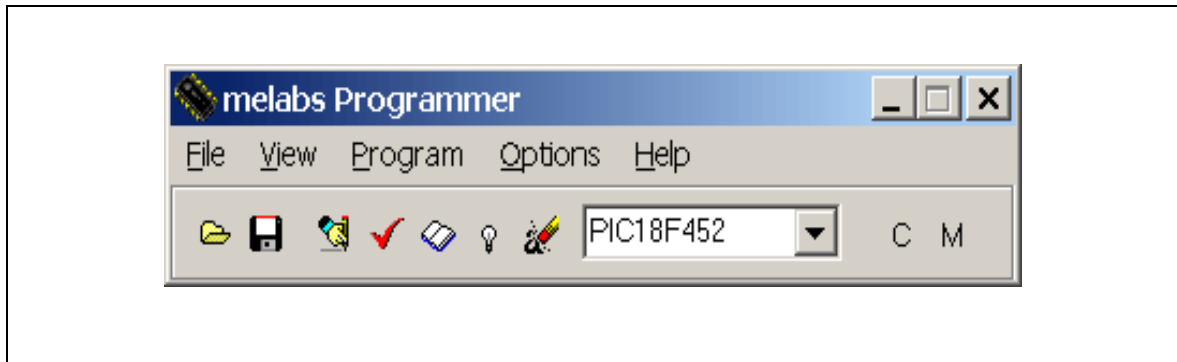


Figure 2.7: Melabs Programmer toolbar

Programmer uses a serial port to interface to the computer. This makes it compatible with computers that don't have parallel ports. It also allows the use of a USB-to-Serial adapter for those computers that only have USB ports. Figure 2.6 show the picture of MelabsU2 Programmer. The programmer board is specifically designed for In-Circuit Serial Programming (ICSP). An adapter is available to allow the programming of DIP-packaged PICs from 8 to 40 pins. The programmer is also compatible with the complete line of Programming Adapters. This allows user to program almost any ICSP-capable PIC in almost any package. The programmer board measures only 1.8" x 2.3". Power is supplied by a 15VDC, 500mA AC Adapter. A dual color LED indicates programmer status. The connection to the computer is via a standard 9-pin serial cable.

Some features of this programmer is it have a Fast serial operation at 115,200 bps, can be used with USB-to-Serial adapters, have dual-colour indicator shows ready/busy states, in-Circuit Serial Programming (ICSP) connector for interface to project board, full featured software included with support for all ICSP-capable PIC microcontrollers, compatible with Microchip HEX format files and with all Programming Adapters. The programmer includes software for Windows 98/Me/NT/2000/XP [10]. This software will make sure the user to control the programmer and set the configuration bits on the PIC. The software may be run as a



standalone application or launched from most program editor/IDE packages like MicroCode Studio (same as installed in the computer at the FKEE lab). Figure 2.7 shows the example melabs programmer toolbars.

The Serial Programmer software is compatible with the standard Microchip HEX format files and any assembler or compiler for PIC microcontrollers can be used to create the program, including MPASM, CCS C, PicBasic, or PicBasic Pro. The software allows user to set configuration bits on the PIC with an easy-to-use list of options and each configuration option is selectable in a drop-down list. Configuration data may be read from a hex file or from a PIC [10]. The consolidated view-memory window function to view each section of memory in the PIC with a click and a right-click gives the choice of viewing ASCII, Decimal, or Hexadecimal. A formidable list of options allows customizing the way of interact with the software and all operation can be control for example what areas of the device are erased, programmed, and verified. Save mouse clicks with options like "Disable completion messages" and "Erase before programming". The programmer's firmware can be upgraded electronically with the click of the mouse [10].

## CHAPTER 3

### METHODOLOGY

#### 3.0 Introduction

This chapter explains all the methodologies for development of Pickbot robot. It gives review of all method that being used in designing and constructing this project. This chapter also explains in theory of how the circuit process as well as the components that will be use and the work flowchart.

Due to the project, several methods have to be implemented to make this project success and the experiment method was identified. By experimenting, the theories that have been searched are supported and make the project work physically, not just theories. By the way, research in several of sources act as a guide line to know which method is ideal and which are not suitable.

The procedure to complete this project begins with the data collection and literature review that have been done during first semester of the project. The study on circuitry of power supply, servo motor and microcontroller are important to select the right component and tools that has to be used.

### **3.1 Project Planning Schedule**

Project planning Schedule is one of the important part during develop the project because will guide and shown the step during project development. Appendix A Show the Project Planning Schedule for “Projek Sarjana Muda 1” (PSM1) and “ Projek Sarjana Muda 2“ (PSM 2)

#### **3.1.1 Flow Chart Description**

There is some method that has been applied to make this project run smoothly and make this project work systematic. The flow chart will be used as a guide line to develop this pickbot. Figure 3.1 show the progress or the sequence of this project. From the flow chart, in order to complete this project, data collecting and gathering is needed. Collect the data and research mean collect the source from the books, journals, internet, website and so on which are related with the project as a reference. After literature review step there are 3 main steps are needed to complete this project. The 3 main steps are hardware development, circuit development and software development. The final Step is to integrate all the3 main parts to complete the pickbot project and archive the objective of this project

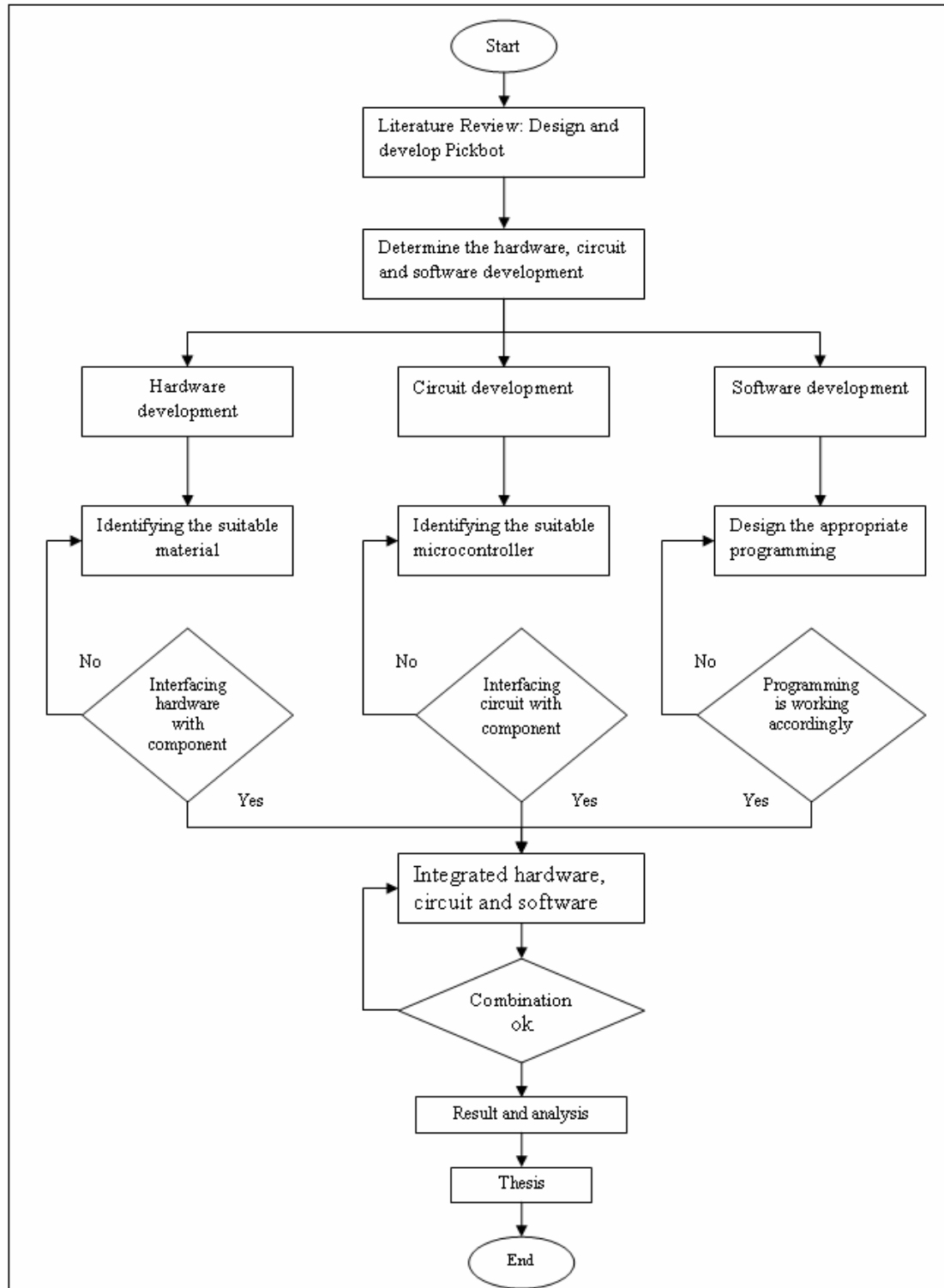


Figure 3.1: Flow chart of the pickbot project

## **3.2 Hardware Development**

In fabricating a robot (hardware), the most important criteria that is need to take into consideration is the weight. The reason why weight is emphasized is the actuator that will be use is servomotor. Unlike the pneumatic and hydraulic actuators, electric actuators (servo motor) capable of lifting very low weight comparatively. For the hardware, must be low in weight to achieve high efficiency. The material for the hardware (body) which needs to be selected must be low in weight and high or moderate strength. The best material which meets all the need is acrylic.

### **3.2.1 Acrylic**

In this hardware part, acrylic has been chosen because this material is a useful, clear plastic that resembles glass, but has properties that make it superior to glass in many ways. Acrylic is used to make various products, such as shower doors, bath enclosures, windows and skylights. It is chosen over glass for many reasons. It is many times stronger than glass, making it much more impact resistant and therefore safer. Falling against an acrylic shower door will not likely break it. Baseballs that crash through glass windows will, in most cases, bounce off acrylic windows. Acrylic also insulates better than glass, potentially saving on heating bills.

### 3.2.2 Design Specification

Pickbot robot consist 4 main parts that need to build. The part is base, lower arm, upper arm and gripper. Each part has a servo motor as an actuator to move the pickbot robot. Table 3.1 shows the specification of pickbot project. Figure 3.2 above show the technical view of the pickbot that going to be developed. The blue colour shows the actuator (servo motor). The yellow colour shows the base of the pickbot. The green colour is the lower and upper arm. The pink colour is the gripper.

Table 3.1: Specification of pickbot project

Part	Length	Weight
Stand/base	5 inch	100 g
Lower arm	8 inch	80 g
Upper arm	2 inch	20 g
Gripper	5 inch	50 g

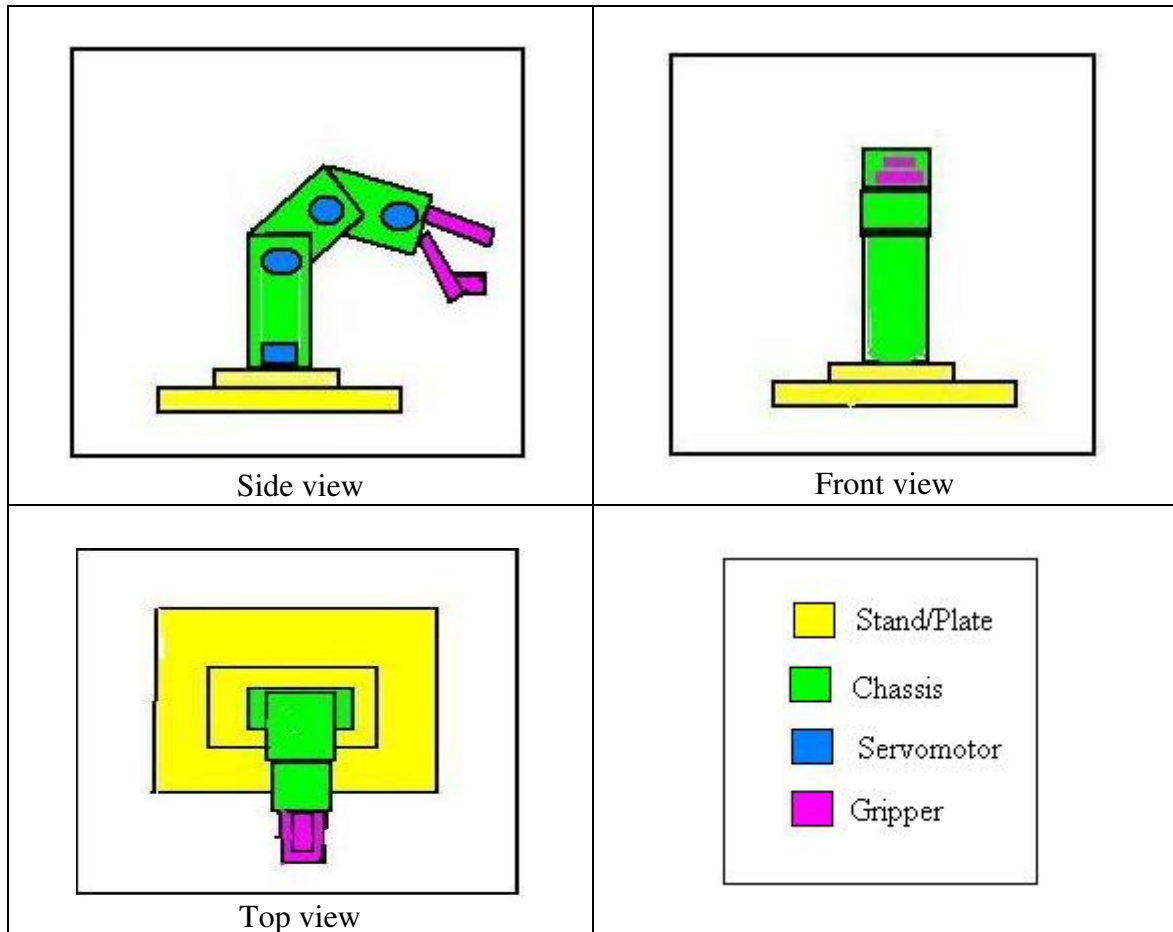


Figure 3.2: The design for pickbot project

### 3.2.3 Circuit Development

The important thing for circuit development is need to chose the component that will be used to build the main circuit. The component is chosen because of specification that will suitable for the project. This research is doing by literature review in previous chapter. Table 3.2 below show the list component that will be used to developed this project.

Table 3.2: List of component

Component	Explanation / specification	Company
PIC 16F877	Microcontroller: To control the input and output	Microchip Technology inc.
Resistor	10 K ohm	
voltage regulator	Give exact value +5v to microcontroller	7805CT
capacitor	100uF (4 quantity), 22uF (2 quantity)	
Reset switch	For reset application	
Crystal 20Mhz	Give the signal clock to microcontroller	
Switch (SPWT)	Input switch for this pickbot project	



This pickbot project has two main circuits that need to be developed. This two main circuit is depending on each other. The circuits that need to build are:

- Supply circuit
- Main circuit

### **3.3.1 Supply Circuit**

Figure 3.3 below shows the supply circuit for this project. This circuit shows the diagram to perform +5V Dc supply. The source of this supply circuit is +9V Dc .Voltage regulator 7805CT is use to get the stable +5V Dc supply. This is because the microcontroller PIC16F877 chip operating voltage range is 2.0V to 5.5V and current 25mA. “heatsink” is used in voltage regulator to make sure the chip is operating in maximum temperature.

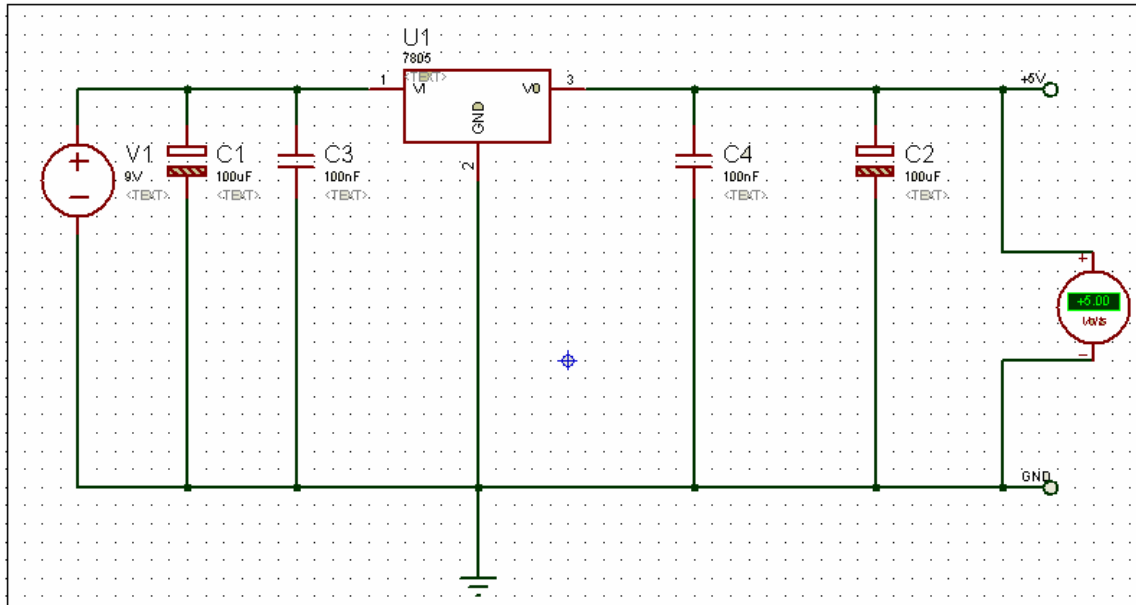


Figure 3.3: Supply circuit

### 3.3.2 Controller Circuit

The controller circuit needed +5V dc to operating. This explain in supply circuit above. Figure 3.4 shows the controller circuit The controller circuit is consist the microcontroller PIC16F877 chip. There are 5 port in this microcontroller that can be use as input and output port, port A, port B, port C, port D and port E. To assign the port become output and input, it must using programming. This main circuit will control the servo motor movement. In this project servo motor will be connected to port C which is pin 15,16,17,and 18 in microcontroller chip. One switch will be used as a input to this project. This switch will be assign in port B which is pin 33 in microcontroller chip.

Table 3.3: Pin assignment for microcontroller

Port	Pin	Function
Port B	RB0	Switch
Port C	RC0	Base/stand( servo motor 1)
	RC1	Lower arm( servo motor 2)
	RC2	Upper arm(servo motor 3)
	RC3	Gripper (servo motor 4)

This controller circuit also have need addition circuit to complete which is

- Oscillator circuit
- Reset circuit

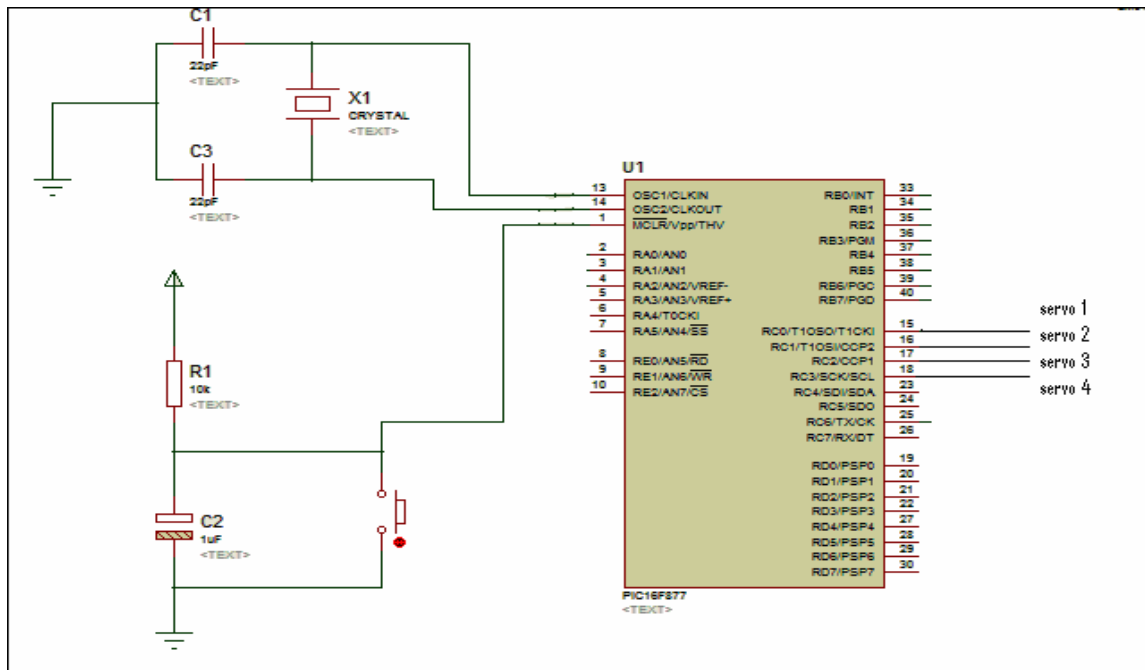


Figure 3.4: Controller circuit

### 3.3.2.1 Oscillator Circuit

Oscillator circuit is function to supply clock signal stable and accurate to microcontroller. The frequency signal clock range from 4Mhz to 20 Mhz depend on the microcontroller specification to execute the task or instruction. Crystal kuartza is one of the component that supply the signal clock to the microcontroller. Figure 3.5 show the example of crystal 20 MHz . For PIC16F877 its can used crystal 4 MHz to 20 MHz In this Project, crytal 20 MHz will be used to get the faster instruction execute because if the higher crystal value, the microcontroller can execute the instruction fast. The crystal is to decide the frequency used in microcontroller. Figure 3.6 below show the connection of the oscillator circuit.



Figure 3.5: Crystal 20 MHz

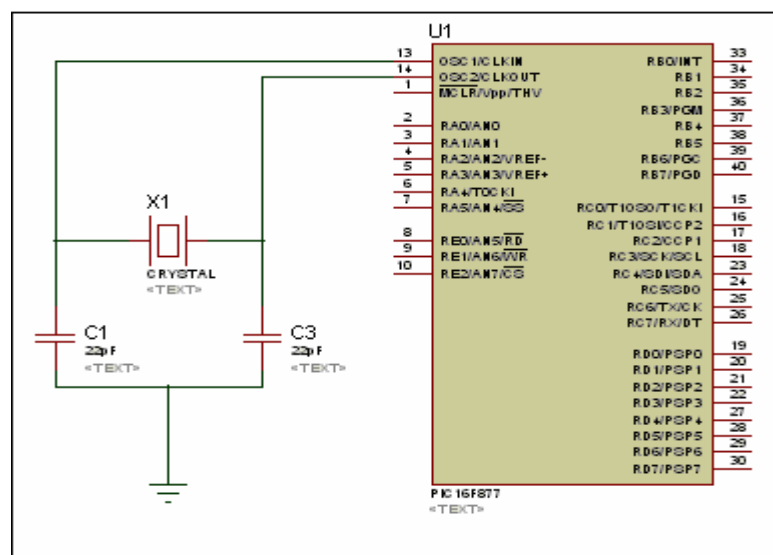


Figure 3.6: Oscillator circuit

### 3.3.2.2 Reset Circuit

Function reset circuit is to set a 'clear Mode' which is initial mode for microcontroller circuit. The component that needed in this circuit is resistor and switch is connected to MCLR/Vpp in microcontroller chip. If the resistor is not connected to this circuit, the microcontroller circuit will always in clear mode when the supply is connected. When the switch is press, it will make the resistance very low from MCLR/Vpp pin and make the microcontroller is grounded. Figure 3.7 shows the connection of reset circuit.

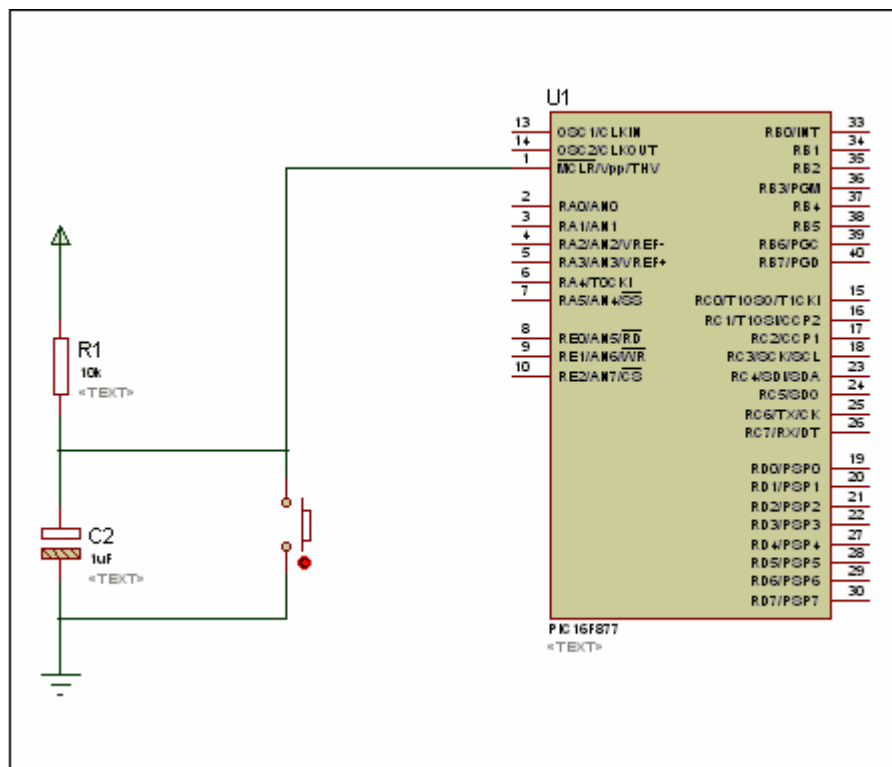


Figure 3.7: Reset circuit

### 3.4 Software Development

It is necessary to build a flow chart for the programming build because it will guide and generate the idea to build the program for this project. Figure 3.8 shows the programming flow chart of this pickbot project

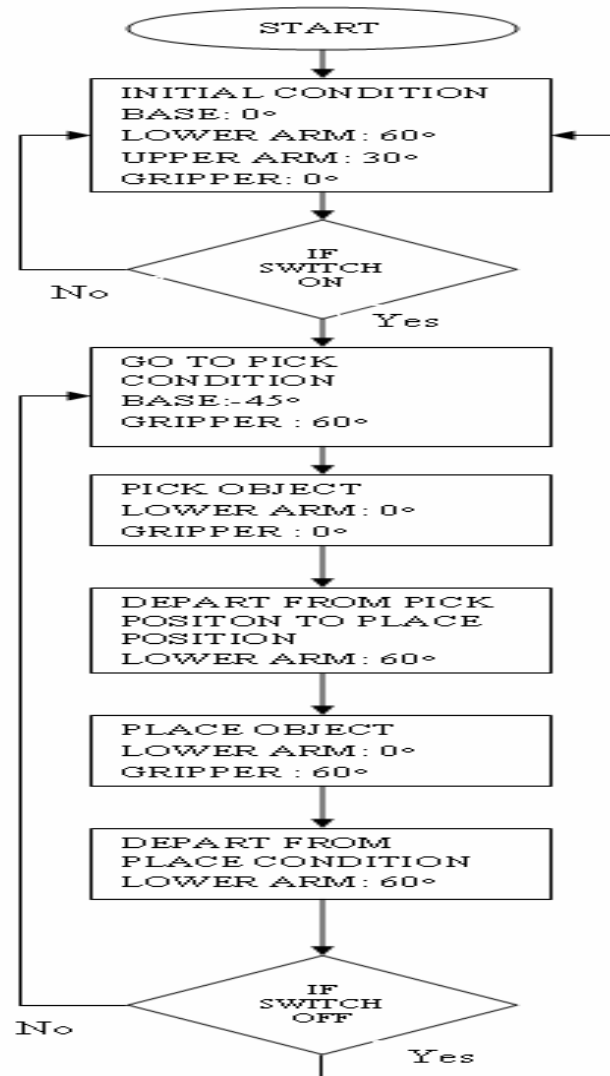


Figure 3.8: Programming flow chart

After few research on programming of PIC16F877 microcontroller, PIC basic Pro has been choose as the programming language because of the simplicity in developing the servo motor driver program. The key command in controlling a servo is Pulseout command. Pulseout command is to generate a pulse on pin of specified period This command used required the PIC pin to be output signal and the output period of the signal is can be controlled by programming.

### **3.4.1 Software**

An assembly language is a low-level language for programming computers. It implements a symbolic representation of the numeric machine codes and other constants needed to program a particular CPU architecture. This representation is usually defined by the hardware manufacturer, and is based on abbreviations (called mnemonics) that help the programmer remember individual instructions, registers, etc. An assembly language is thus specific to certain physical or virtual computer architecture (high level language).

Assembler is needed to convert the low language to the machine language or high level language. This needed because microcontroller only can read the machine language or high level language. Assembly language is more easy compare to machine language. In this project, after few research on programming of PIC16F877 microcontroller, PBP has been choose as the assembly language because of the simplicity in developing the servo motor driver program. The key command in controlling a servo is Pulseout command. Pulseout command is generate a pulse on pin of specified period This command required the PIC pin used to be output signal and the output period of the signal is can be controlled by programming.

### **3.4.1.1 Picbasic Pro language**

The Picbasic pro compiler (PBP) makes its even quicker and easier way to program microcontroller. The English-like Basic language is much easier to read and write other assembly language. This assembly language use easier language such as IF, THEN, ELSE, GOTO etc

By using the 20 MHz crystal in this project, the pulseout resolution is depend upon the oscillator frequency. Since in this project were uses 20MHz oscillator, the period will have a 2 microsecond resolution. Servo motor Hitec HS 422 data sheet, to move the servo motor in neutral condition or 0° is needed 1.5milisecond. Therefore to generate the 1.5 ms from the microcontroller ( $1.5\text{ms}/2\text{ us} = 750\text{ pulse}$ )

### **3.4.1.2 MicroCode Studio**

MicroCode Studio is one of the software can be use to compile the assembly language to a machine language. Figure 3.9 below show the MicroCode Studio software. The programming that builds using PBP language can be compile into a Machine code using this software.



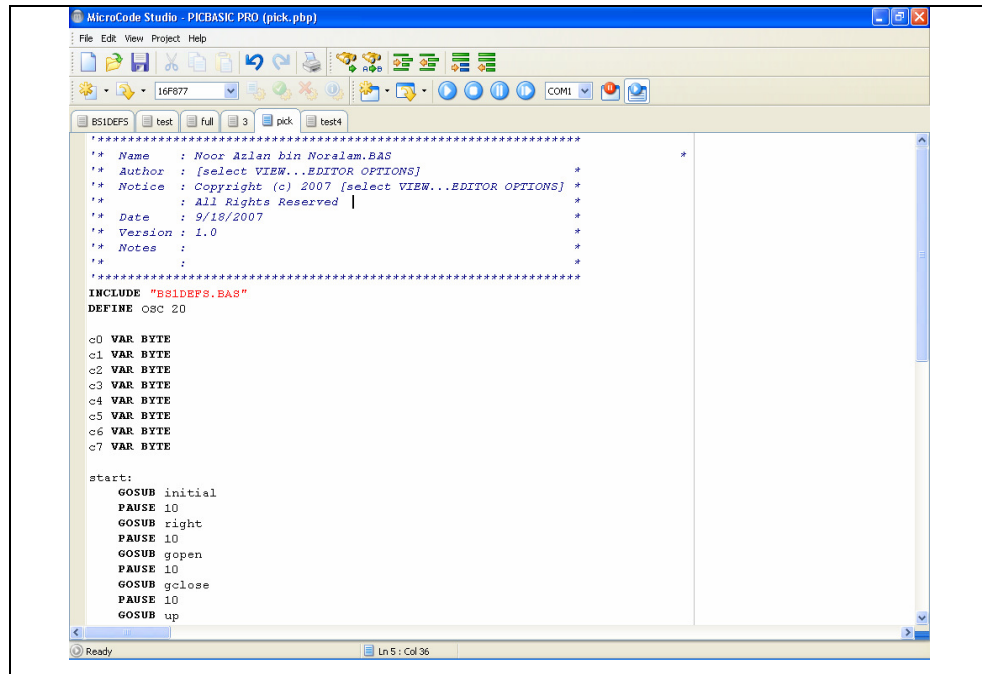


Figure 3.9: Microcode Studio software

### 3.4.1.3 Melab Programmer

Melab U2 programmer is the hardware will be used to burning (install) program into microcontroller PIC16F877. Using this programmer is the easier way to burn the program into microcontroller. After finish the programming that will write in Microcode studio software and compile, the Melab U2 programmer will burn the programming into PIC16F877 chip. Figure 3.11 show process programming using Melab U2 programmer. Figure 3.12 show the Melab U2 programmer hardware.

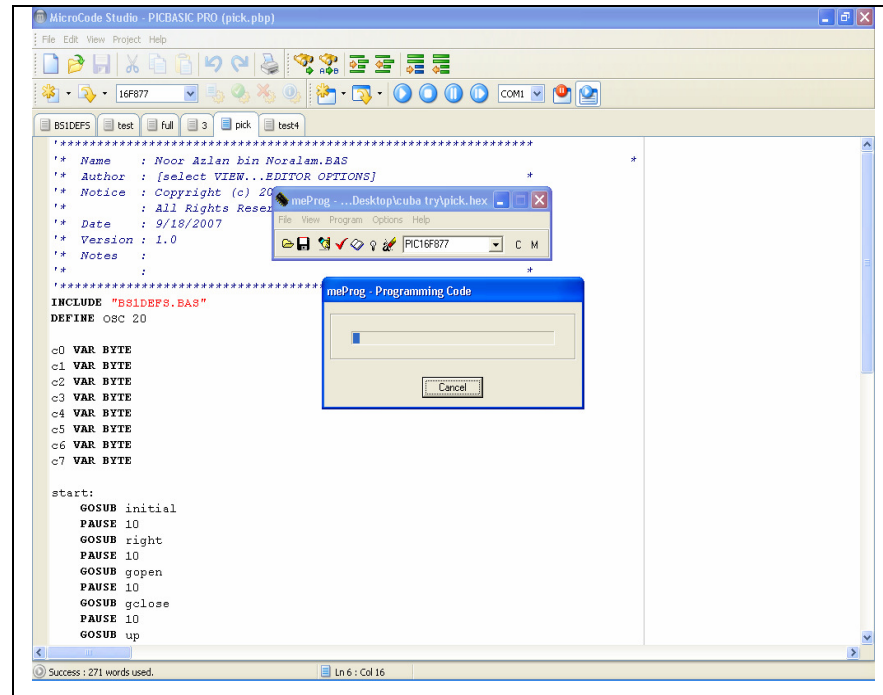


Figure 3.10: Burning process into PIC16F877 using Melab U2 programmer

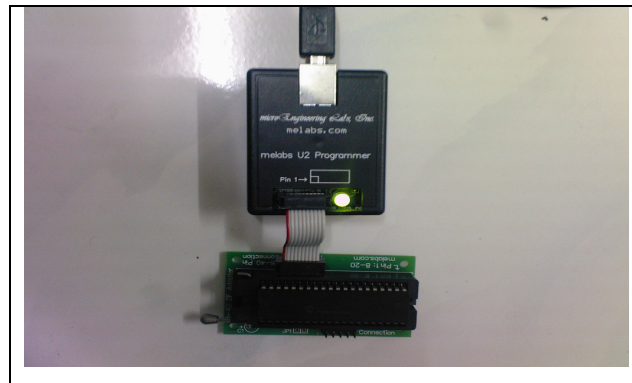


Figure 3.11: Melab U2 programmer

## **CHAPTER 4**

### **RESULT AND ANALYSIS**

#### **4.0 Introduction**

This chapter will discuss all the finding and results after constructing the hardware, circuit and software. These results will be analyzed to ensure the finding is same as expected result. This chapter also will be discusses the limitation and problem occur when integrating all hardware, circuit and software as well as the finding that are not same with expected result.

#### **4.1 Hardware Result**

Hardware result is show the result of building the pickbot body. The important of this part is to make sure the design of pickbot can be build using the chosen material. Figure 3.2 show the design of pickbot robot. As the result of build body pickbot robot is show below. This design has to take all consideration such as weight and the servo

torque to get the successful result. Figure 4.1 below show the picture part of pickbot robot has been build using acrylic. Figure 4.2 show the full picture of pickbot robot.

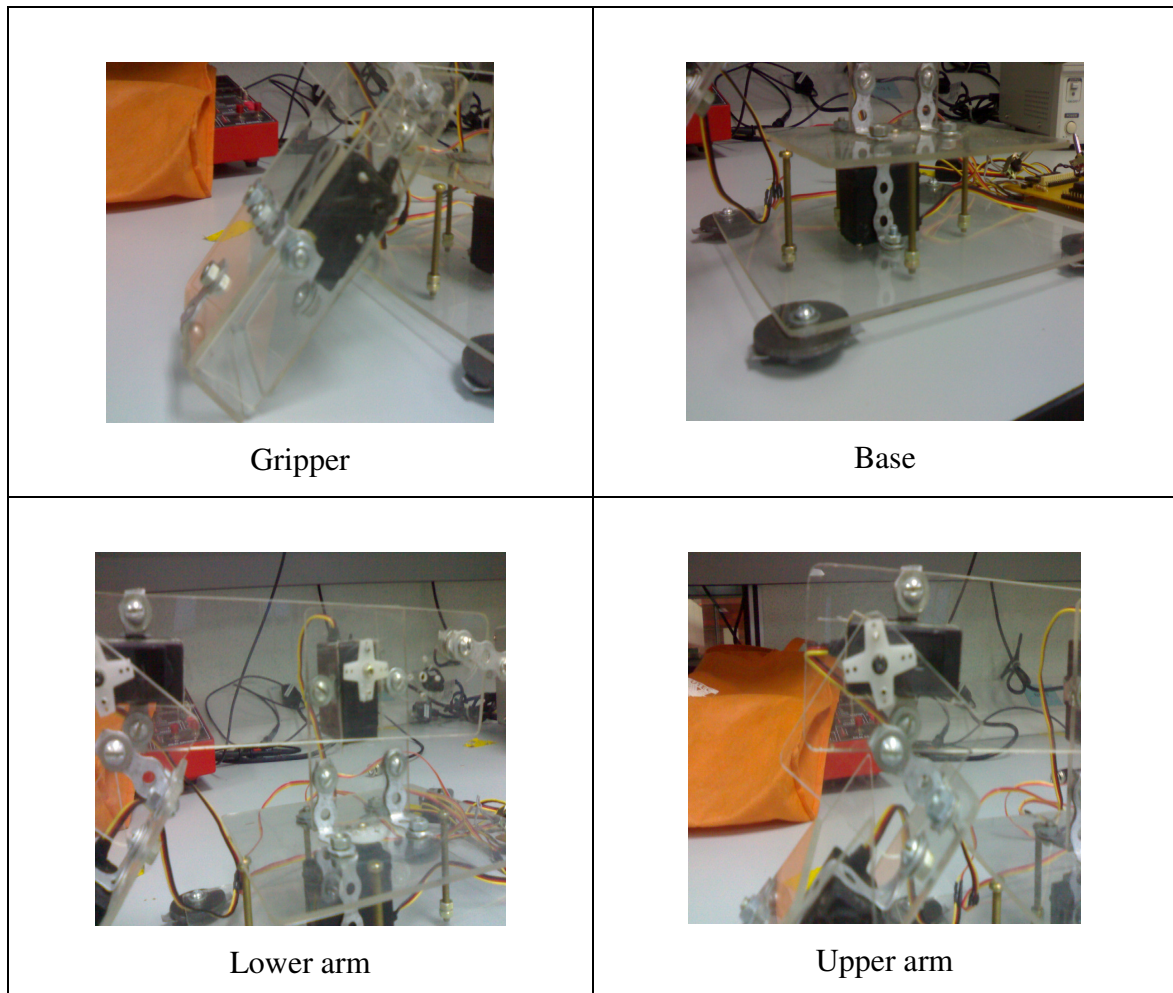


Figure 4.1: Part of pickbot robot

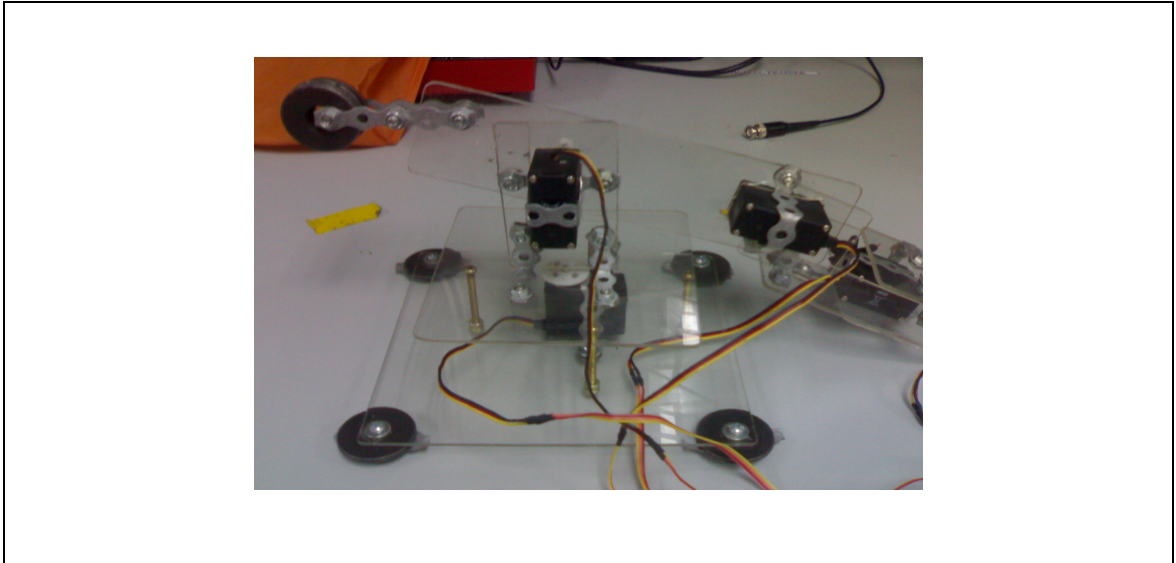


Figure 4.2: Full picture of pickbot robot

#### 4.1.1 Weight Analysis

Weight analysis is the important element that needs to be considering build the pickbot robot. The estimation of weight by mathematical calculation is needed to know the maximum weight mass.

From the formula of force:  $F = mg$

Where

$m$  = mass

$g$  = gravity

From the formula of torque,  $t = F \times h$

Where

$h$  = distance from gravity point

Torque servo motor,  $t = 3.3 \text{ Kg/cm}$  (from servo motor data sheet)  
 $= 0.33 \text{ N/m}$

Mathematical Calculation for designed pickbot robot:

$$\begin{aligned} \sum t &= \sum t (\text{actuator}) - \sum t (\text{weight of arm}) \\ &= 0.33\text{N/m} - [(\text{Base weight} \times g \times h) + (\text{lower arm weight} \times g \times h) + (\text{upper arm} \\ &\quad \times g \times h) + ((\text{gripper weight} + \text{load}) \times g \times h) \\ &= 0.33 \text{ N/m} - [(0.06 \text{ kg} \times 9.821 \times 0.045\text{m}) + (0.050 \text{ kg} \times 9.821 \times 0.1\text{m}) + (0.045 \\ &\quad \text{kg} \times 9.821 \times 0.12\text{m}) + ((0.045\text{kg} + \text{load}) \times 9.821 \times 0.02\text{m})] \\ &= 0.33\text{N/m} - [(0.0265) + (0.0491) + (0.0529) + (0.0088) + (\text{Load} \times 9.821 \times \\ &\quad 0.02)] \end{aligned}$$

$$0 = 0.33\text{N/m} - [(0.1373) + (\text{load} \times 9.821 \times 0.02)]$$

Load = 0.982Kg or 982 gram

From the calculation above the weight which the first joint is capable lifting is 0.982Kg. However this calculation is base on pface state. After eliminating the attributed factor roughly the minimum weight which can be lifted by first joint is about 40% of load that is

$$\begin{aligned} \text{Net load} &= 40/100 \times 0.982\text{Kg} \\ &= 0.392\text{Kg} \text{ or } 392 \text{ gram} \end{aligned}$$

## 4.2 Circuit Result

Circuit is the most important part to complete this project. By doing the simulation using Orcad PSpice to make sure the connection of the circuit of PIC16F877 is enable to complete the task to control the pickbot robot. Figure 4.3 below show the picture of circuit that has been build refer to simulation on Orcad PSpice. Figure 4.4 show the full picture of the circuit.

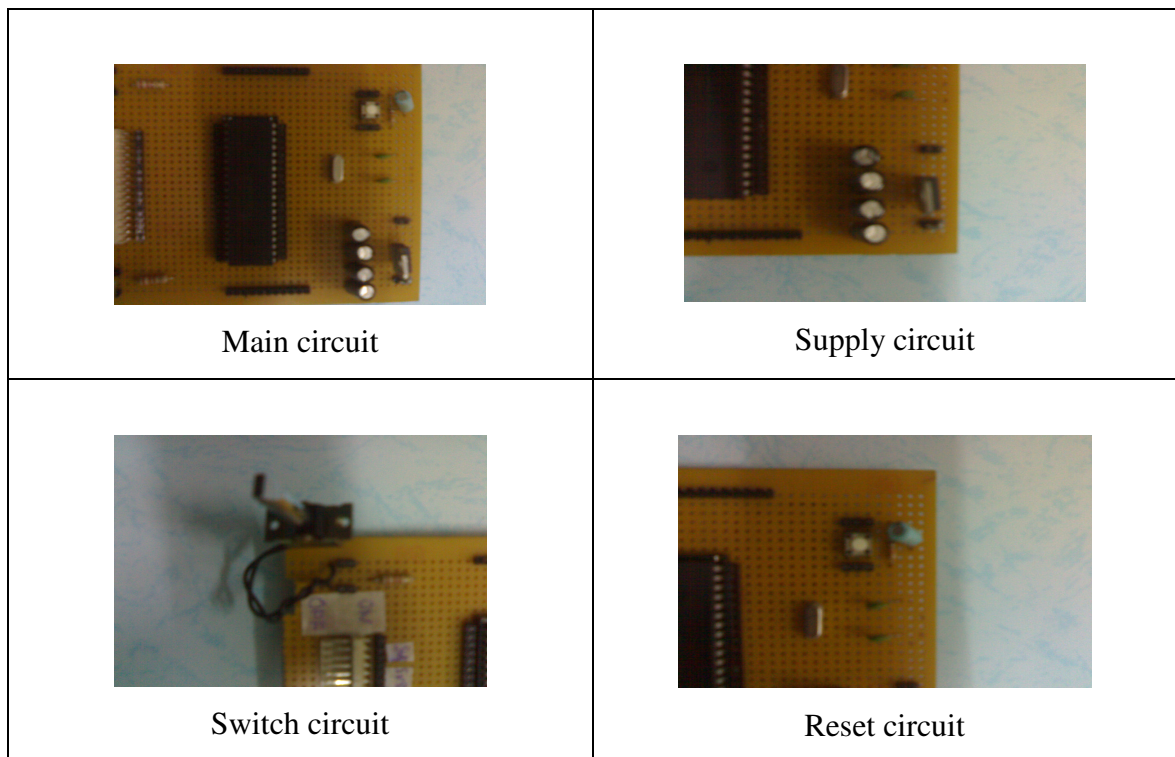


Figure 4.3: Circuit pickbot

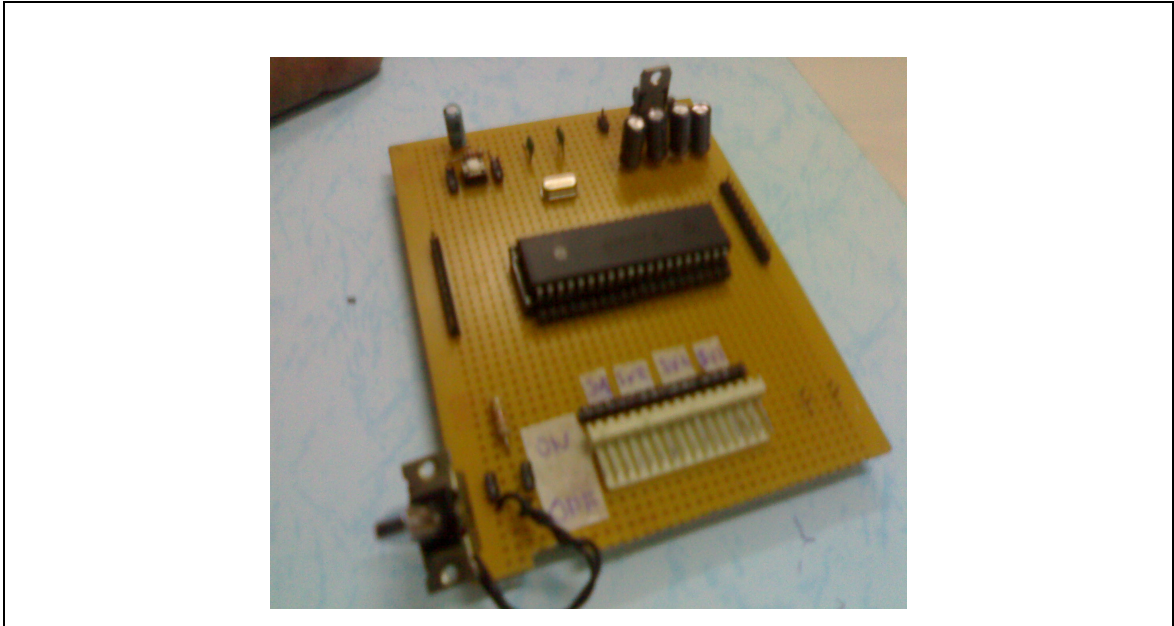


Figure 4.4: Complete pickbot project circuit

#### 4.2.1 PIC16F877 interface with servo motor Analysis

PIC16F877 is the most suitable microcontroller to control servo motor movement because of stable and easy to interface the motor with the circuit. The needed on controlling servo motor movement is Pulse Width Modulation (PWM). One of features that have in PIC16F877 is on board only 2 PWM generator modules. This project needs to control 4 servo motor in 1 PIC16F877 chip, so the on board PWM generator cannot apply in this project. Another problem that occurs in on board PWM is the PWM generator operates based on the timer divisions of the input oscillators. At 20 MHz, a 5%-10% duty cycle every 20ms is simply not possible. PIC16F877 need to be slow down to 800 kHz to get the 20ms period. At that clock rate, serial communication at 9600 baud rate is seriously affected and the resolution is still more than consideration to control servo motor, about 20 $\mu$ s per turn. Figure 2.3 show how servo are controlled.



From the diagram, by providing a 900uS to 2100uS PWM signal every 20mS to control Hitec HS422 servo motor. As the result, generating the 4 channel of the PWM is needed using a programming. This will discuss in 4.3.1 Software Result.

### 4.3 Software Result

This software result show that the program that has been implemented in this pickbot project. The analysis to control servo motor using a programming has been made in order to complete this project. The most important in this part is the programming to control pickbot the based on the program flow chart in figure 3.9.

#### 4.3.1 Servo Motor Analysis

PWM is needed to control servo motor movement. After a few research in PIC16F877, Picbasic Pro has been chose as the programming language because of the simplicity in developing the servo motor driver program. The key command in controlling is the *pulseout* command. The *pulseout* command requires the PIC16F877 pin used to give output the signal and the period constant to tell how long to send the pulse.

Based on the circuit development, 20MHz crystal input oscillation has been used in PIC16F877 circuit. This will develop 2us resolution for *pulseout* command. The period constant that is used in center block of code needs to result in a 1.5ms pulse. Therefore the actual value is used in the command is  $(1.5 \text{ ms} \div 2 \text{ us} = 750)$ . Figure 4.5

show the movement of servo motor based on pulse. Servo motor movement analysis is show in table 5.1

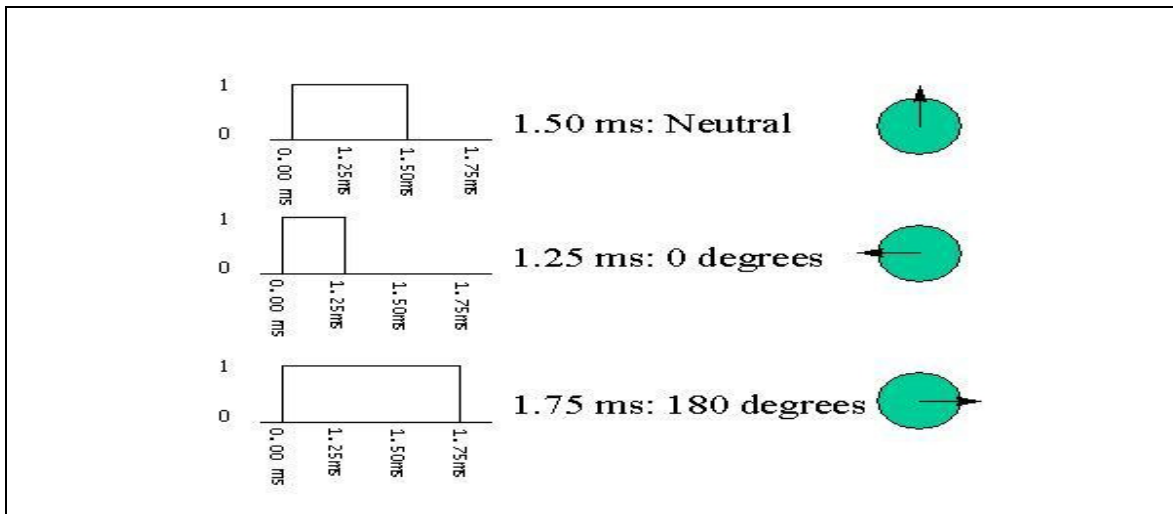


Figure 4.5: Servo motor movement analysis

Table 4.1: Servo motor movement analysis

Degree of movement	Period	<i>Pulseout</i> command
-90	2.25ms	1125
-60	2.00ms	1000
-30	1.75ms	875
0	1.50ms	750
30	1.25ms	625
60	1.00ms	500
90	0.75ms	375

### 4.3.2 Program Analysis

Language Picbasic pro is the suitable programming for this project because of the simplicity. The follows is the basic element which involves in a servo motor driver program. The full program of this pickbot project will show in Appendix B.

```
define OSC 20
```

Figure 4.6: Command of initialization code

This code is important to synchronize the circuit and the programming coding. *Define OSC 20* means the 20 MHz crystal that used as oscillated input in PIC16F877 circuit.

```
c0 var byte  
c1 var byte  
c2 var byte  
c3 var byte
```

Figure 4.7: Command of variables

Variable are where temporary data is stored in a Picbasic Pro program. They are created using VAR keyword. Variables may be bits, bytes or words. Space for each variable automatically allocated in the microcontroller's RAM by Picbasic Pro. Figure 4.7 show the example of variable that used in this pickbot project.

```
main:
  if portB.0=0 then
    goto start
  else
    goto condition
  endif
  goto main
```

Figure 4.8: Command for switch

Figure 4.8 show the program that used for switch in this project. In the circuit design, the switch is active low mean when the PIC16F877 get a Low"0" signal from the switch, it will proceed the main program and if get the High"1" signal, it will proceed the initial condition program.

```
start:
  gosub right
  pause 10
  gosub gopen
  pause 10
  gosub gclose
  pause 10
  gosub up
  pause 10
  gosub left
  pause 10
  gosub gopen1
  pause 10
  gosub up1
  pause 10
  goto start
end
```

Figure 4.9: Command main program

```

condition:
  gosub initial
  pause 10
  goto condition
end

```

Figure 4.10: Command initial position

```

right:
  for c1=1 to 100
    pulsout 8,500
    pulsout 9,625
    pause 20
  next
  return

```

Figure 4.11: Command of subroutine

Figure 4.9 and 4.10 is the heart of the programming command; this command will tell the sequences of the program According to define variables. *Gosub* mean the jump to the subroutine. Figure 4.11 show the one example of subroutine program that has been used in this pickbot project. When *return* statement is used in the subroutine program, executed resumes with the statement following the last executed *gosub* statement.

The subroutines command in figure 4.11 program is the important to know because this step which is to control servo motor movement. The instruction *for c1=1 to 100* send pulse signal 50 times to servo motor to hold the servo motor in the position chosen. *Next* is needed to count the *for* instruction. *Pulsout 8,500* commands are to give the pulse out, 8 is the pin number for pin RC0 to control servo motor 1. The detail pin assigned show in table 3.3. 500 is the command servomotor movement assigned, the table 4.1 show the detail of the movement analysis. *Pause 20* is to wait 20 ms is the delays make sure the command run systematically.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATION

#### 5.0 Introduction

This chapter will conclude the development of the project. This chapter will also discuss the recommendation for this project for future development or modification.

#### 5.1 Conclusion

The development of this project can be considered as low in cost relatively. After few researching the suitable material, acrylic is the most suitable compare to aluminum. The torque requirements will be out of the range of the servos motor if using aluminum. The pickbot robot also needs to be light, cheap to manufacture. Since the degree of freedom is determined by number of servo, it is limited to 4 degree of freedom. This is because as the number of servo is increasing, the weight of the robot wills increase. The PIC16F877 is the most suitable microcontroller as a driver servo motor because of the

features and the easier way to write the programming for the pickbot project. The pulse width analysis of the servo motor cannot be given signal for too long. It needs to take a rest period about 20ms. Otherwise the servo motor will lose its control and spoil. Overall this pickbot project move is perfect and it can pick and place the object smoothly.

## **5.2 Future Recommendation**

This pickbot robot can be improved to be more versatile. Below are the elements that can be improved in this project.

1. Add sensor in the picking and placing object to remove the possibility of error in placing and picking object.
2. Add a limit switch at the end-effectors to stop gripping when the limit switch is activated. This feature makes the robot can grip any size of object.
3. Increase the degree of freedom by adding more servo motor to make the robot pick and place object at any point.

### **5.2.1 Costing and Commercialization**

This pickbot robot has achieved the objective and expected result. The costing to produce this pickbot robot is around RM350.00. This is a raw cost because of using the material list below

Table.5.1: Project Costing

	Material	Cost
Hardware	Acrylic	RM 50.00
Circuit	Based on circuit design	RM100.00
Robot actuator	Servo motor (4 unit)	RM200.00
	Total	RM350.00

From the table 5.1 above shows the proper material selected to build this pickbot robot with a low cost and high quality. This pickbot robot can be commercialized as a studies tools and the industry to implement the technology or system design.



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APPENDIX A

PSM 1	Dis	January				February				March				April			
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17
Title selection			■														
Supervisor Release				■													
Literature Review (Data Collection)			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Proposal Preparation				■	■	■											
Proposal Submission					■	■											
Proposal Correction and Resubmission						■	■										
Additional Research and Data Collection							■	■	■								
Slide Preparation							■	■	■	■							
Seminar Presentation										■							
Draft Report Preparation and Submission											■	■					
Prepare Full Report PSM 1											■	■					
Log Book Entrance				■	■	■	■	■	■	■	■	■	■				
Log Book Submission													■				
Full Report PSM 1 Submission														■			
Hardware Specification											■	■	■	■	■	■	■
Hardware Test and Troubleshooting											■	■	■	■	■	■	■

Project Planning Schedule PSM 1

PSM 2	Julai		August			September				October			November				
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17
Literature Review	■	■	■	■	■	■	■	■	■	■	■	■	■				
Hardware Interfacing Circuit	■	■					■	■	■								
Hardware Test and Troubleshooting			■	■	■	■	■	■									
1st draft & log book submission				■	■												
Program Develop (Software)					■	■	■	■	■								
Program Test and troubleshooting						■	■	■	■								
Integrating Hardware and Software							■	■	■	■							
Testing Stage Integration								■	■	■	■						
Result and Analysis										■	■						
Project review and Correction										■	■	■					
2nd draft report & log book Submission											■	■					
Final Presentation and Project Demo													■	■			
Thesis	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Final draft & log Book Submission														■	■		
Thesis Submission															■		

Project Planning Schedule PSM 2

## APPENDIX B

```

'*****
'* Name      : Pickbot project program.BAS          *
'* Author    : Noor Azlan bin Noralam              *
'* Notice    : Copyright (c) 2007 [select VIEW...EDITOR OPTIONS] *
'*           : All Rights Reserved                  *
'* Date      : 9/17/2007                            *
'* Version   : 1.0                                  *
'* Notes     :                                       *
'*           :                                       *
'*****
include "BS1DEFS.BAS"
define OSC 20

c0 var byte
c1 var byte
c2 var byte
c3 var byte
c4 var byte
c5 var byte
c6 var byte
c7 var byte
c8 var byte

main:
  if portB.0=0 then
    goto start
  else
    goto condition
  endif
  goto main

  condition:
    gosub initial
    pause 10
    goto condition
  end

  start:
    gosub right
    pause 10
    gosub gopen
    pause 10
    gosub gclose
    pause 10
    gosub up
    pause 10
    gosub left
    pause 10
    gosub gopen1
    pause 10
    gosub up1
    pause 10
    goto start
  end

```

```
initial:
    for c0=1 to 100
        pulsout 8,750
        pulsout 9,500
        pulsout 11,625
        pause 20
    next
    return

right:
    for c1=1 to 100
        pulsout 8,500
        pulsout 9,625
        pause 20
    next
    return

gopen:
    for c2=1 to 100
        pulsout 11,875
        pause 20
    next
    return

gclose:
    for c3=1 to 100
        pulsout 11,625
        pause 20
    next
    return

up:
    for c4=1 to 100
        pulsout 9,750
        pause 20
    next
    return

left:
    for c5=1 to 100
        pulsout 8,1000
        pulsout 9,625
        pause 20
    next
    return

gopen1:
    for c6=1 to 100
        pulsout 11,875
        pause 20
    next
    return

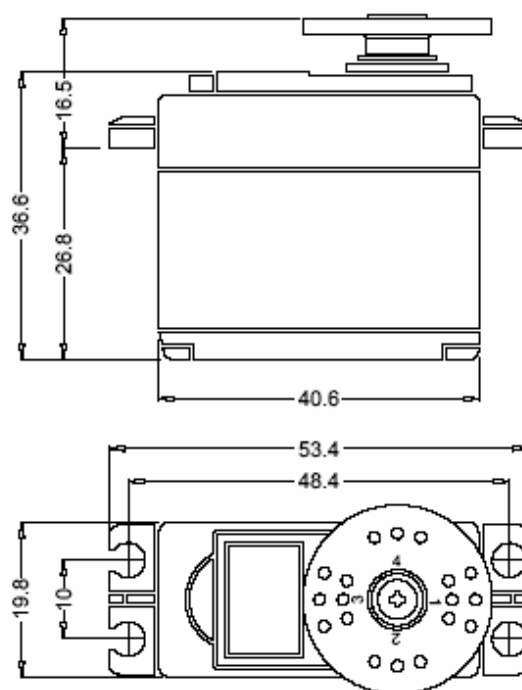
up1:
    for c8=1 to 100
        pulsout 9,750
        pause 20
    next
    return
```

## APPENDIX C

## ANNOUNCED SPECIFICATION OF HS-422 STANDARD DELUXE SERVO

## 1. TECHNICAL VALUES

CONTROL SYSTEM	: +PULSE WIDTH CONTROL 1500usec NEUTRAL	
OPERATING VOLTAGE RANGE	: 4.8V TO 6.0V	
OPERATING TEMPERATURE RANGE	: -20 TO +60°C	
TEST VOLTAGE	: AT 4.8V	AT 6.0V
OPERATING SPEED	: 0.21sec/60° AT NO LOAD	0.16sec/60° AT NO LOAD
STALL TORQUE	: 3.3kg.cm(45.82oz.in)	4.1kg.cm(56.93oz.in)
OPERATING ANGLE	: 45° ONE SIDE PULSE TRAVELING 400usec	
DIRECTION	: CLOCK WISE/PULSE TRAVELING 1500 TO 1900usec	
CURRENT DRAIN	: 8mA/IDLE AND 150mA/NO LOAD RUNNING	
DEAD BAND WIDTH	: 8usec	
CONNECTOR WIRE LENGTH	: 300mm(11.81in)	
DIMENSIONS	: 40.6x19.8x36.6mm(1.59x0.77x1.44in)	
WEIGHT	: 45.5g(1.6oz)	



## 2. FEATURES

3-POLE FERRITE MOTOR  
LONG LIFE POTENTIOMETER  
DUAL OILITE BUSHING  
INDIRECT POTENTIOMETER DRIVE

## 3. APPLICATIONS

AIRCRAFT 20-60 SIZE  
30 SIZE HELICOPTERS  
STEERING AND THROTTLE SERVO FOR CARS  
TRUCK AND BOATS

## APPENDIX D



# PIC16F87X

## 28/40-Pin 8-Bit CMOS FLASH Microcontrollers

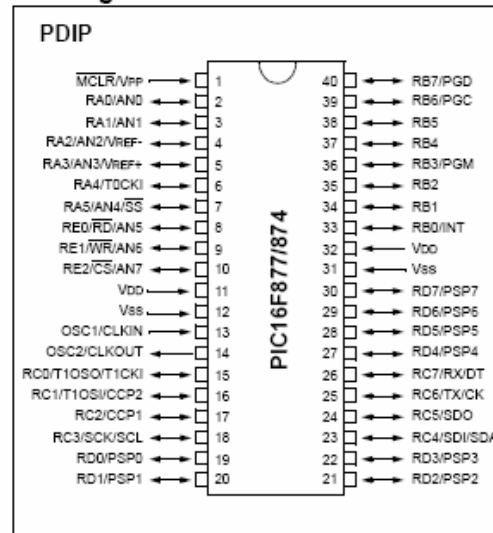
### Devices Included in this Data Sheet:

- PIC16F873
- PIC16F876
- PIC16F874
- PIC16F877

### Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input  
DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,  
Up to 368 x 8 bytes of Data Memory (RAM)  
Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and  
Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC  
oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM  
technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two  
pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature  
ranges
- Low-power consumption:
  - < 0.6 mA typical @ 3V, 4 MHz
  - 20 µA typical @ 3V, 32 kHz
  - < 1 µA typical standby current

### Pin Diagram



### Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler,  
can be incremented during SLEEP via external  
crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period  
register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master  
mode) and I<sup>2</sup>C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver  
Transmitter (USART/SCI) with 9-bit address  
detection
- Parallel Slave Port (PSP) 8-bits wide, with  
external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for  
Brown-out Reset (BOR)

## APPENDIX E

**XT49U**

Vishay Dale

**Resistance Welded Holder Type Crystal Unit**

The XT49U series is an industry standard AT cut crystal housed in a HC-49U package. It is our standard resistance weld type quartz crystal.

**FEATURES**

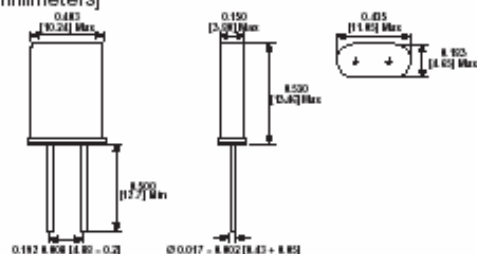
- Low cost
- Industry standard
- Excellent aging
- Wide frequency range
- 'AT' cut crystal

**STANDARD ELECTRICAL SPECIFICATIONS**

PARAMETER	SYMBOL	CONDITION	UNIT	MIN	TYPICAL	MAX
Frequency Range	$F_0$		MHz	1.8432		125
Frequency Tolerance	$\Delta F/F_0$	at 25°C	ppm	± 10	± 30	± 50
Temperature Stability	TC	ref to 25°C	ppm	± 10	± 30	± 50
Operating Temperature Range	$T_{OPR}$		°C	- 20		+ 70
Storing Temperature Range	$T_{STG}$		°C	- 40		+ 85
Shunt Capacitance	$C_0$		pF			7
Load Capacitance	CL	Customer Specified	pF	10		Series
Insulator Resistance	IR	100V <sub>CC</sub>	MΩ	500		
Drive Level	DL		μW		100	500
Aging	Fa	at 25°C, per year	ppm	- 5.0		+ 5.0


**EQUIVALENT SERIES RESISTANCE (ESR) AND MODE OF VIBRATION (MODE)**

FREQUENCY RANGE (MHZ)	MAX ESR (Ω)	MODE	FREQUENCY RANGE (MHZ)	MAX ESR (Ω)	MODE
1.8432 to 1.999	650	Fundamental	6.000 to 7.999	50	Fundamental
2.000 to 2.999	500	Fundamental	8.000 to 12.999	35	Fundamental
3.000 to 3.499	250	Fundamental	13.000 to 32.000	25	Fundamental
3.500 to 3.999	150	Fundamental	24.000 to 29.999	60	3 <sup>rd</sup> Overtone
4.000 to 4.999	100	Fundamental	30.000 to 79.999	40	3 <sup>rd</sup> Overtone
5.000 to 5.999	80	Fundamental	80.000 to 125.000	90	5 <sup>th</sup> Overtone

**DIMENSIONS** in inches [millimeters]**ORDERING INFORMATION**

XT49U MODEL	R OTR	- 20 LOAD	SP OPTIONS	4M FREQUENCY/MHZ
	Blank = Standard R = - 40°C to + 85°C	Blank = Series - 16 = 16pF - 20 = 20pF - 30 = 30pF - 32 = 32pF	Blank = Standard SL = Sleeve SP = Spacer	

## APPENDIX F

 <b>PRODUCT DATA SHEET</b>		Material Type: <b>Acrylic</b> Product Number: <b>64641</b>
Processing Data	English Values	Metric Values
Injection pressure	10,000-20,000 psi	69-138 MPa
Melt Temperature	400-475°F	204-246 °C
Mold Temperature	75-150 °F	24-66 °C
Material Drying	4 hrs @ 200 °F	4 hrs @ 93 °C
Dew Point	5 °F	- 15 °C
Moisture Content	< 0.01%	<0.01%
<b>Physical</b>		
Specific Gravity	1.16	1.16
Mold Shrinkage, 1/8" (3.2mm)	0.005-0.006 in/in	0.5-0.6 %
<b>Mechanical</b>		
Impact Strength, Notched 1/8" (3.2 mm)	1.2 ft lbs/in	64 J/m
Impact Strength, Unnotched 1/8" (3.2 mm)	15.0 ft lbs/in	801 J/m
Tensile Strength	5,000 psi	34 MPa
Tensile Elongation %	10 +	10 +
Tensile Modulus	0.21 x 10 <sup>6</sup> psi	1447 MPa
Flexural Strength	7,500 psi	52 MPa
Flexural Modulus	0.25 x 10 <sup>6</sup> psi	1723 MPa
<b>Electrical</b>		
Volume Resistivity	10 <sup>10</sup>	10 <sup>10</sup>
Surface Resistivity	10 <sup>10</sup>	10 <sup>10</sup>
Static Decay, MIL B-81705C	< 2 seconds	< 2 seconds