

DC MOTOR CONTROLLED BASED ON
MICROCONTROLLER

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Signature : _____

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*Special dedicated,
To my beloved family
'AG's Family'
Thanks for all the support and understanding
To my lovely friends
Thank for all your helps
May Allah bless all of your kindness.*

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Bismillahirrahmanirrahim...

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ABSTRACT

The DC motor uses in drive system in many industrial applications are still significant. In this project, the DC motor controlled based on microcontroller PIC 18F4550 is proposed. The controller will control the speed and direction of the DC motor. The microcontroller will generate the PWM (Pulse Width Modulation) signal and use to control the speed of motor. The DC drive will be used to control the direction of the DC Motor. The analysis of the drive performance is also carry out in this project. The experiment showed that the motor speed can be controlled via microcontroller from zero to maximum speed easily at low cost since PIC has built in programmable timers, ports and interruption where no extra hardware is needed.

ABSTRAK

Motor arus terus yang digunakan dalam sistem pemacu dalam pelbagai aplikasi industri masih ketara. Dalam projek ini, motor arus terus dikawal berdasarkan PIC 18F4550 dicadangkan. Pengawal akan mengawal kelajuan dan arah motor arus terus. Mikropengawal akan menjana isyarat PWM (*Pulse Width Modulation*) dan digunakan untuk mengawal kelajuan motor. Pemacu motor akan digunakan untuk mengawal arah motor arus terus. Analisis prestasi pemacu juga dijalankan dalam projek ini. Eksperimen menunjukkan bahawa kelajuan motor boleh dikawal melalui mikropengawal dari sifar ke kelajuan maksimum dengan mudah pada kos yang rendah di mana mikropengawal telah pun mempunyai pemasa programkan, port dan gangguan di mana tiada perkakasan tambahan diperlukan.

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LIST OF ABBREVIATION

UMP	-	Universiti Malaysia Pahang
DC	-	Direct Current
PIC	-	Peripheral Interface Controllers
PWM	-	Pulse Width Modulation
S/W	-	Software
H/W	-	Hardware
PMDC	-	Permanent magnet direct current
IC	-	Integrated circuit
JP	-	Jurutera Pengajar
LCD	-	Liquid Crystal Display
PSM	-	Projek Sarjana Muda
LED	-	Light Emitting Diode

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CHAPTER 1

INTRODUCTION

1.1 General

DC motor is a machine that converts electrical energy into mechanical energy by supplying dcpower (voltage and current). DC motor can be seen everywhere. For example in home appliances which are washer, rolling mills in factories and robotic arm control in electronic field. These applications demand high speed control accuracy and may be direction too. The DC motor uses in drive system in many industrial applications are still significant. This is all result from the availability of speed controllers in wide range, easily and many ways. For example in speed control using voltage control method, when the motor get the full power supply where the voltage is high, it will rotate at maximum speed. When no power is supplied, the motor will start to slow and eventually stop as the power is decrease. By varying the voltage supplied, the motor will rotate according to the voltage given.

DC motor is useful in many applications because it provide high torque due to flux and torque are perpendicular causes they have less inertia characteristic. By mastering in handling both speed and direction of DC motor will definitely gain advantages in motor performance. The simplicity of control speed made DC motors to be common in devices ranging from toys, house appliances, and robotics to industrial applications.

1.2 Control of DC motor

1.2.1 Speed Controller Method

In this project, the speed of DC motor will be controlled based on the width of the pulse that generated by PIC 18F4550. The pulse generated is called Pulse Width Modulation (PWM). The bigger the width of PWM signal, the speed will become faster and vice versa. The microcontroller will give the pulse signal after receiving command by user by pressing the push button. The speed can be increased or decreased.

1.2.2 Direction Controller Method

For direction control method, it is also will wait for the user command by pressing push button. The PWM signal will be given to motor driver before to the motor. The circuit has two buttons for speed control where the first one for increasing speed and the other one for reducing the speed of DC motor.

1.3 Objective of project

The objective is a guideline and goal in completing the project. The main core of this project is to design and implement a system to control both DC motor's speed and direction using microcontroller. The system is able to control the motor's speed at desired speed using PWM technique.

1.4 Scope of Project

Based on the objective of the project, there are several scope has been outlined. The first scope of this project is the use of PIC18F4550 as a microcontroller. Secondly, the project built a hardware system for speed control and also forward and reverse directions using permanent magnet DC motor.

1.5 Project contribution

This project has a big potential in industry as now many machine is using motor to operate. So by controlling both speed and direction of DC motor will give more advantages or functions that can be applied in many applications. All the functions are

controlled by a microcontroller which given advantages in term of cost, size and many more. By that specialty, the implementation of this project for any application will be more convenient and efficient.

The contribution patterns of project are:

1. In factories, controlling DC motor can be seen at machines used. For example, the rolling mills, hoist and others.
2. In hospital where during a CT scan to detect cancer or other disease, the table slowly passes through the center of a large x-ray machine while the patient lies very still on the table.
3. In buildings that have elevators for going up and down at desired floor level. For example, shopping malls.

1.5 Report organization

This report consists of five chapters. The content of each chapter is outlined as follows:

Chapter 1 of the report introduces the subject matter with a brief review of the project. The objectives, scope and contribution of project are presented.

Chapter 2 deals with literature review where the previous works related with subject are discussed. This includes the controllers and techniques used to control DC Motor in term of speed and direction.

Chapter 3 describes the proposed method of the project in order to complete the project. Besides that, it also discussed about both hardware and software development and implementation. The hardware section talks about components used in this project. Other than that, the work flow in doing research is also presented.

Chapter 4 states the result obtained during simulation process and a brief discussion about it.

Chapter 5 is summarize of this project and recommendation of future work that can be done.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is about the study and works have been done on DC motor and speed controller. Besides that, it is also briefly discussed on motor drivers.

2.2 DC motor

There are many type of DC motor that are available such as stepper motor, DC motor w/field coil, permanent magnet DC (PMDC) motor, printed circuit board (PCB) motor, gasoline motor and others. These motors have their own advantages and disadvantages and are used in different applications. Stepper motor has a very precise

speed and position control and also has a high torque at low speed. But it is expensive and hard to find. It also requires switching control circuit. While for DC motor w/field coil, it has a wide range of speeds and torque. It is also more powerful than PMDC motor but it requires more current than PMDC due to its field coil that need to be energized. Plus, it also is much heavier than PMDC motor and also hard to obtain.

The printed circuit board (PCB) motor, using permanent magnets, has a configuration radically different from that of the conventional DC motor. The entire armature winding and the commutator are printed in PCB disk (rotor). Due to its several advantages such as high torque, allows it to provide rapid acceleration and deceleration. The motor can accelerate from 0 to 4000 rpm in 10 milliseconds. The motor has no cogging torque because the rotor is nonmagnetic. These motors are particularly suitable for applications requiring high performance characteristics.

Permanent magnet DC motor is small, compact and easy to find. It is also very cheap. But due to its small condition, the disadvantage of this motor is the magnetic field cannot be varied. The variation of DC motor gives much type of control method and its application that can be performed. In conclusion, DC motors have many types and differ with each other in characteristics of the motor and also the use of the motor in appliances.

2.3 Speed control using PWM and switch mode converter

The basic for the pulse width modulation technique is the switching converter. It is an efficient alternative to the linear voltage regulator.

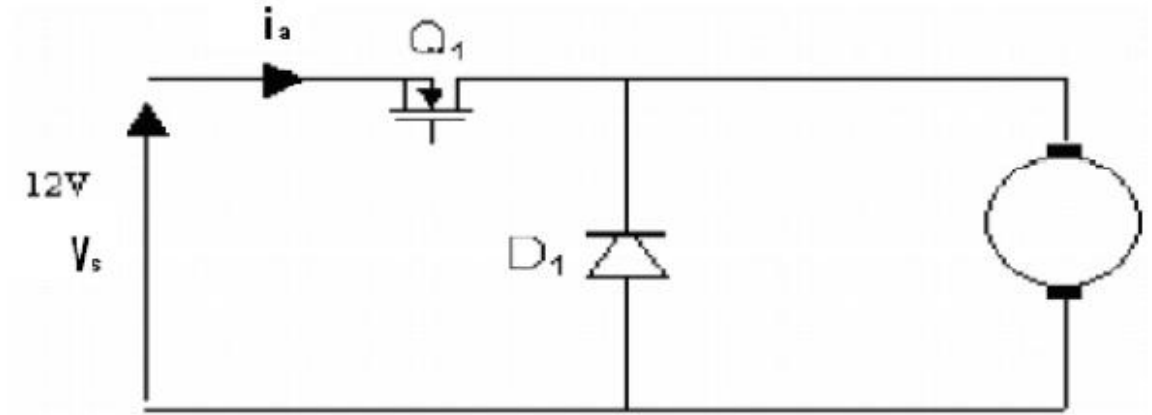


Figure 2.1: Simple motor circuit

Based on simple motor circuit in Figure 2.1, the MOSFET, Q1 act as electronic switch by being either completely on or off. Assuming the switch is ideal, the output is the same as input when the switch is closed and when the switch is open, the output will be zero. Therefore, the average voltage supply to the motor is given by equation 2.1.

$$V_a = \frac{1}{T} \int_0^{DT} V_s dt = V_s D \quad (2.1)$$

Where duty ratio, $D = \frac{t_{on}}{T}$

The average voltage supply to the motor depends on the duty ratio of PWM signal. By controlling the duty ratio (control the width of time on), average output voltage can be control and also the motor.

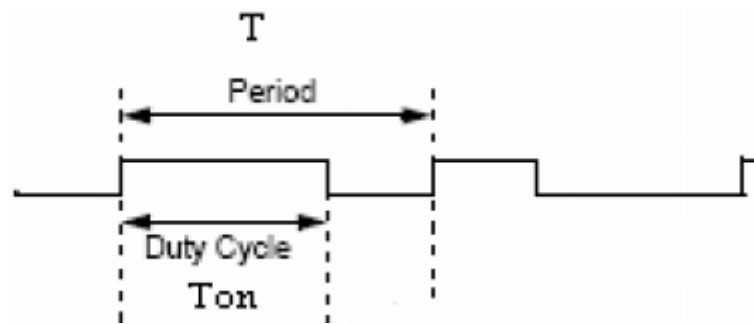


Figure 2.2: PWM signal

Figure 2.2 show the PWM signal to switching the MOSFET. Comparing the triangular signal with the control signal will lead to obtain PWM signal. It is one of the method to obtained the PWM signal. Theoretically, the energy efficiency of this method is fully 100% where when switch is closed, there is no voltage across it resulting to zero power loss. While for switch is open, there will be no current flow in it.

In order to obtain an adjustable DC voltage to control DC motor speed, power electronic converter can be used. Basically, there are two types of converter usually implemented in DC drives which is control rectifier and switch-mode converter.

The switch mode converter usually used for applications requiring position control or fast response since it operate at high frequency that will give faster average output voltage response. Switch mode converter also has higher bandwidth compared to controlled rectifier and the armature current ripple is relatively less than the controlled rectifier circuit when the same amount of inductance present in the armature circuit.

From review, this method has been used by Nur Abu Zaharin Ahmad and Mohd Nasir Taib in their research [1]

In this project, switch mode converter will be used. It will be explained detail in section 3.4.3. It is discussed about motor driver used in this project which is L293D.

2.4 Motor Driver, H-bridge

H-bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. This circuit is often used in robotics and other applications to allow DC motor to run forward in forward or reverse direction. H-bridge will be preferred where a smaller physical size is needed, high speed switching or where the wearing out of mechanical parts is undesirable.

The term “H-bridge” is derived from the typical graphical representation of such circuit as shown in Figure 2.3. It is built with four switches (solid state or mechanical). When the switches S1 and S4 are closed while S2 and S3 are open, a positive voltage will be applied across the motor. By opening both S1 and S4 switches and closing both S2 and S3 switches, the operation of motor will be reversed as the voltage applied is reversed.

Precaution need to be noted that both switches S1 and S2 should never be closed at the same time because it would cause a short circuit at the input voltage source. The condition is called as shoot-through. The switching arrangement of H-bridge is summarize and shown in Table 2.1 below.

Table 2.1 : Switching arrangement of H-bridge

S1	S2	S3	S4	Result
1	0	0	1	Motor moves right
0	1	1	0	Motor moves left
0	0	0	0	Motor free
0	1	0	1	Motor brakes
1	0	1	0	Motor brakes

From review this method has been used by Nur Fadzilah binti Othman in her research [2]

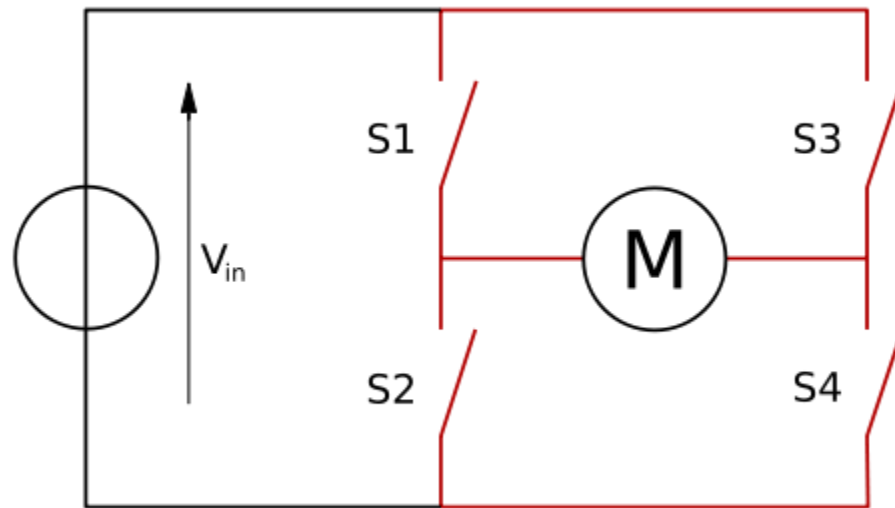


Figure 2.3: H-bridge configuration

CHAPTER 3

METHODOLOGY

3.1 Introduction

This part will be discussed on the overview of the project, the step of research methodology and also about hardware and software implementation briefly.

3.2 Project Overview

As mentioned in the introduction chapter, this project is focused on DC motor speed and direction control system by using PIC18F4550 microcontroller. Figure 3.4 showed the project schematic diagram of the DC motor controller. The details of the schematic diagram are explained in section 3.4. Pulse Width Modulation (PWM) signal

is used in this project where the signal is generated using the microcontroller itself since the microcontroller PIC18F4550 already has built in PWM. The PWM signal will be sent to motor driver (L293D) then given to motor follows which button is pressed. The system has four buttons indicates acceleration and deceleration of speed and also forward and reverse direction of DC Motor. Speed of DC Motor depends on the duty cycle of PWM signal. In Figure 3.1 below show the system block diagram of this project.

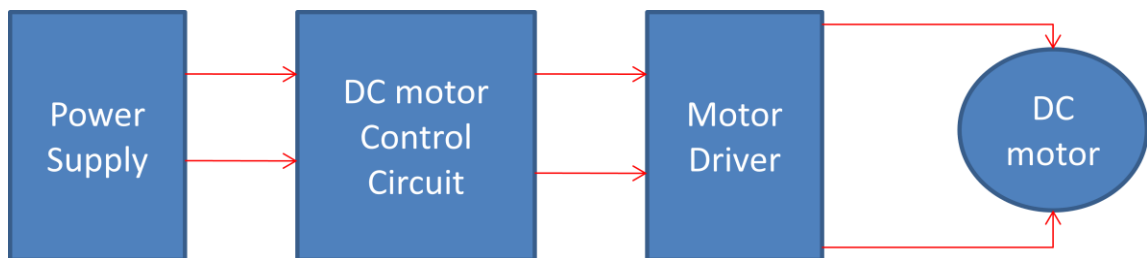


Figure 3.1: System block diagram

3.3 Research methodology

The work of this project is based on the flow diagram shown in Figure 3.2. It shows how works has been done step by step in order to complete the project for both Semester 1 and Semester 2.

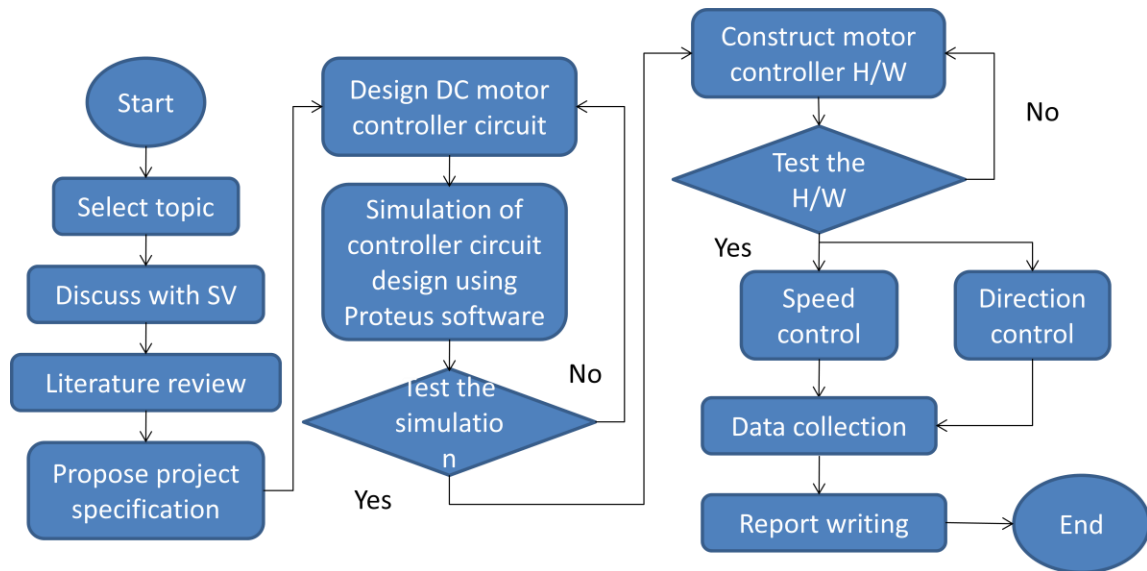


Figure 3.2: Flowchart of research methodology

3.4 Software Implementation

For software implementation, Proteus 7 Professional is used for circuit designation and also simulation. Besides that, PIC C compiler software is used to program the microcontroller in C language.

3.4.1 Proteus software

Proteus software is used to carry out simulation for this project before implemented it in hardware. Proteus software is chosen as it is easy to use and has many

components in library to be chosen. Besides that, it is also easy to interface with PIC C Compiler for the source code. But before that, a complete schematic circuit needs to design first. It starts with placing the parts of components used by searching it in the library section. To make a connection between two components, a wire would be drag to make the connections. The works must be saved first so that any data will not be lost. After the circuit is completed, the source code need to be transferred first before run it. After finished transferring source code, the simulation can be run and the result can be observed such in Figure 3.3.

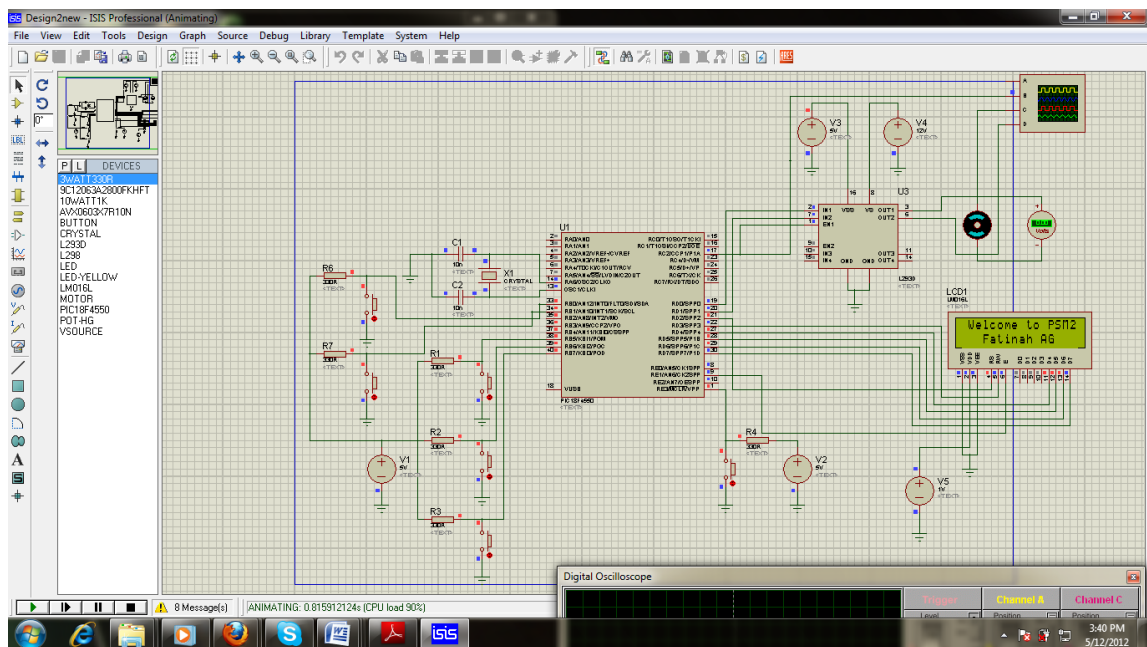


Figure 3.3: Proteus software in run simulation

3.4.2 PIC C Compiler

This PIC C Compiler software is used to build a coding program for this project. The type of language used for this compiler is in C language. For this software, the data also need to be saved first so that it would not be lost. All coding will be build first then must be compile to get the .hex file as shown in Figure 3.4. That .hex file will used to interface with Proteus software in order to run the simulation. Besides that, the .hex file also will be burn into PIC18F4550 using UP00B in Figure 3.13. The source code for this project can be refer at the Appendix section.

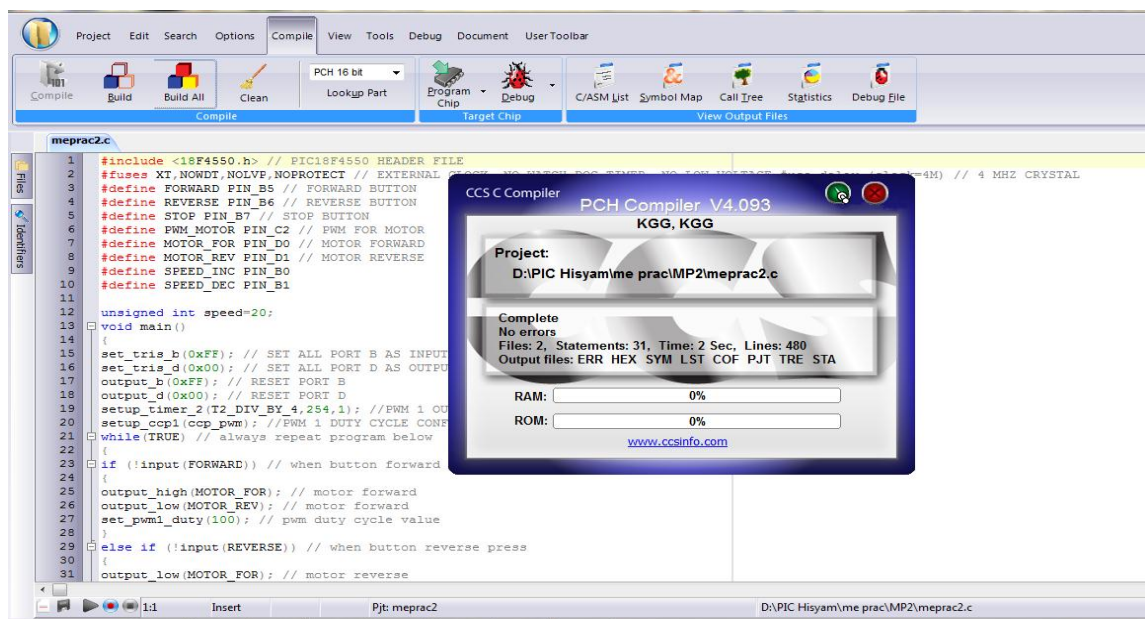


Figure 3.4: PIC C Compiler in compiling mode

3.5 Hardware Implementation

This section discussed the components used in this project. From Figure 3.5 and also Figure 3.6, the project contains of several functions. The detail of each functions is explain in the next section.

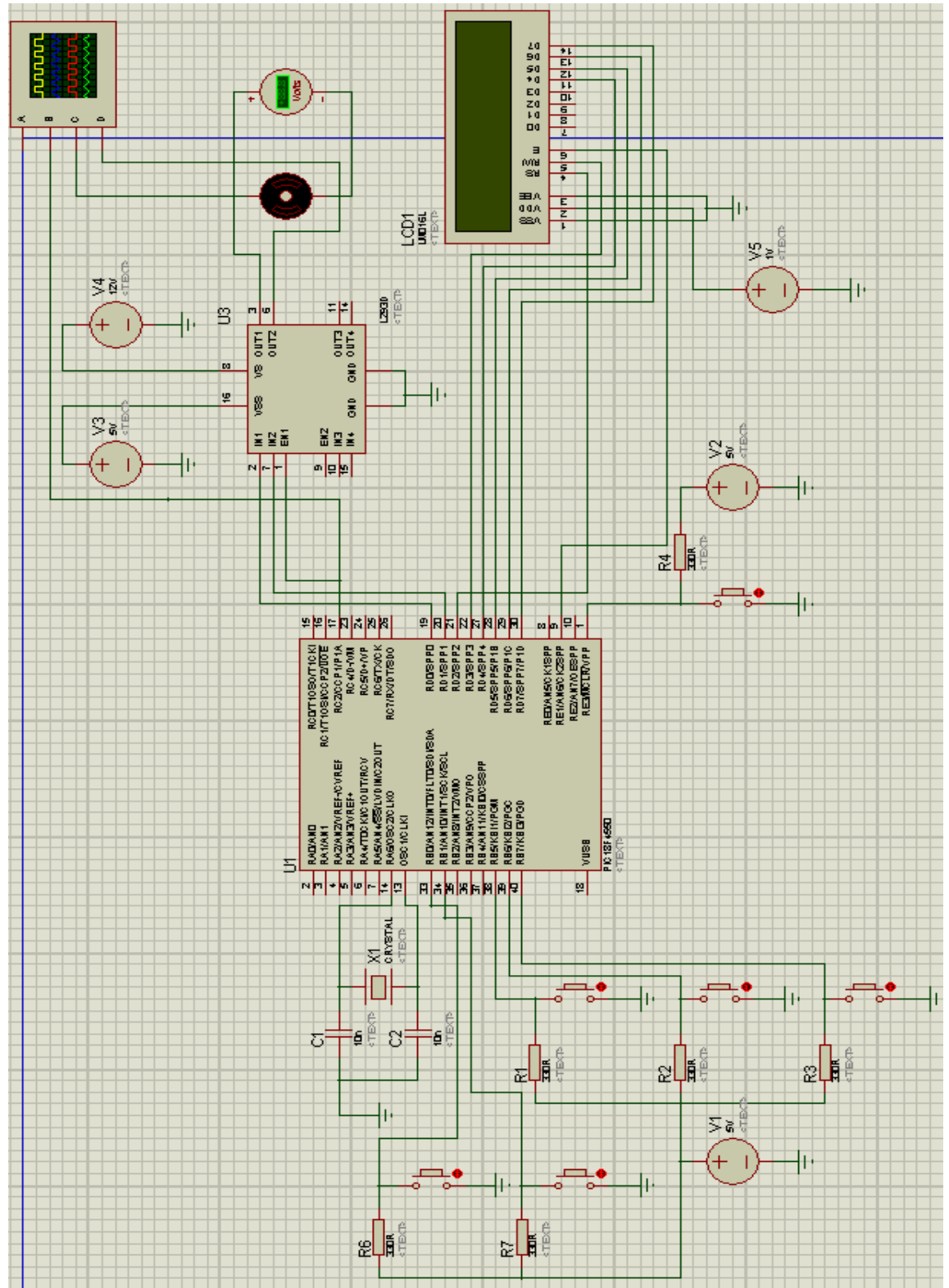


Figure 3.5: Schematic circuit for DC Motor controller

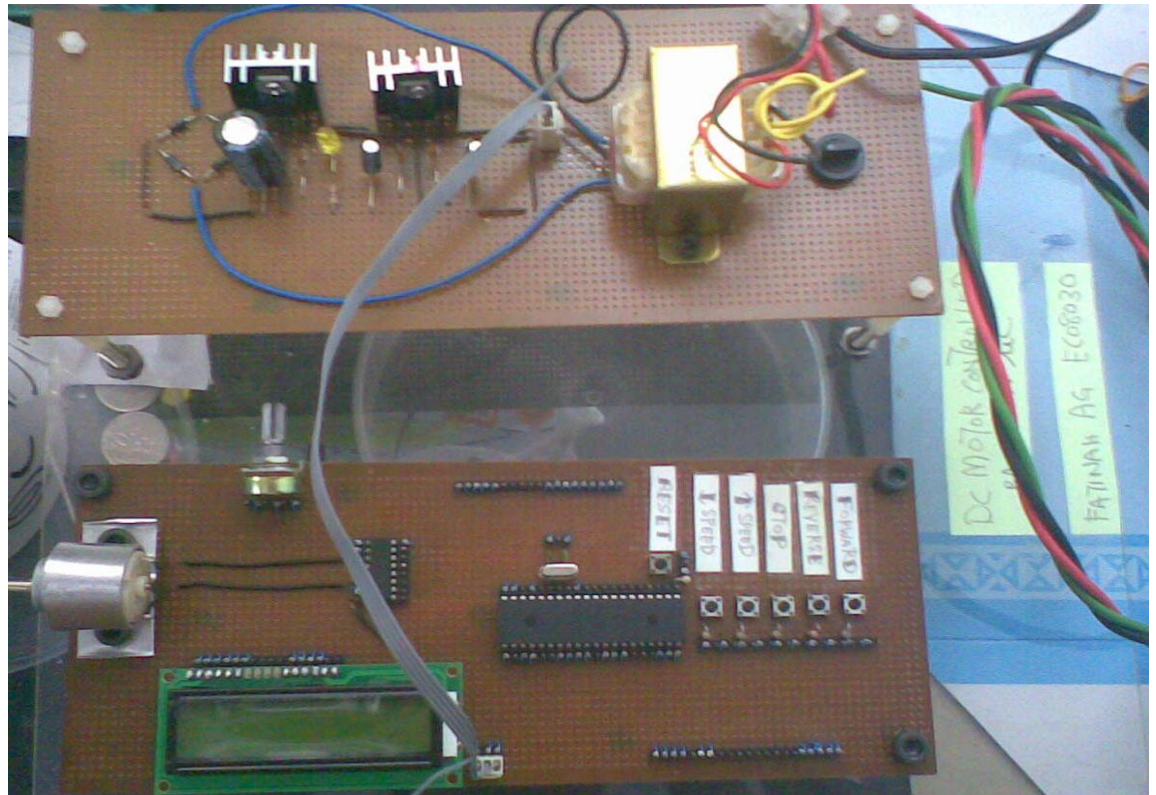


Figure 3.6: Hardware circuit for DC motor controller.

3.4.1 DC motor 12V

In this project, DC motor used is a permanent magnet DC motor. It is chosen due to the following characteristic. The PMDC motor is smaller since the field windings are replaced by permanent magnet and cheaper as well. The absence of the field winding which results to copper loss absent increase the efficiency.

The speed of a PMDC motor cannot be controlled by field flux and thus speed control must be achieved by changing the armature voltage. These motors are therefore used only where motor speeds below base speed are required. Besides that, the used of

PMDC motor in industry is now more popular. For example, MODENAS also used this type of motor in their application.

Figure 3.7 shows the DC motor used in this project which is a permanent magnet 12V DC motor. The specification of this motor is shown in Table 3.1 below. The detail specification about the DC motor can be refer to Appendix section.

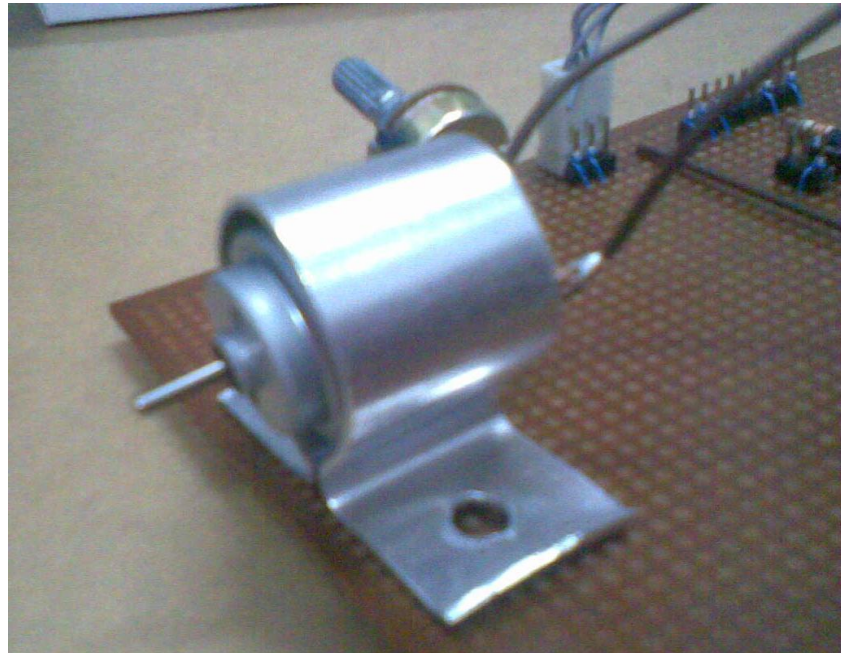


Figure 3.7: 12V PMDC motor

Table 3.1: Specification of DC motor

Manufacturer	Model	Operating range, V	Speed, rpm	Current, A
MABUCHI MOTOR CO. LTD	RK370-CA	12 - 24	5500	0.032

3.4.2 Power supply : +5V and +12V

Most digital logic circuits and processors need a +5 volt power supply. To use these parts we need to build a regulated +5 volt source. Based on Figure 3.8, it starts with an unregulated power supply first. To make a +5 volt power supply, a LM7805 voltage regulator IC (Integrated Circuit) is used. While for +12V power supply, LM 7812 voltage regulator IC is used to feed in VS pin of L293D motor driver to activate or energize the DC Motor.

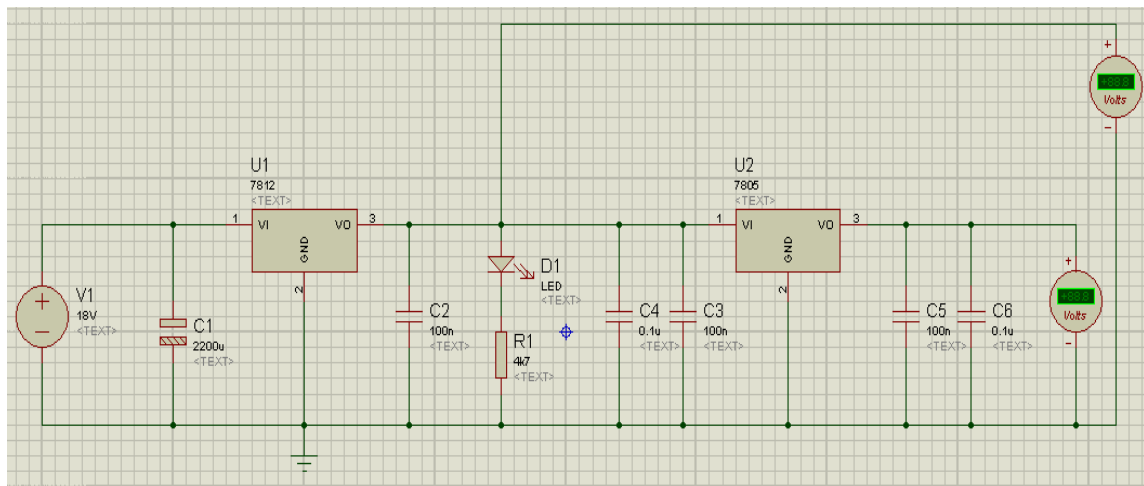


Figure 3.8: Power Supply circuit

The pin configuration of IC 7805 and both voltage regulator, IC 7805 and IC 7812 pictures are shown below in Figure 3.9.

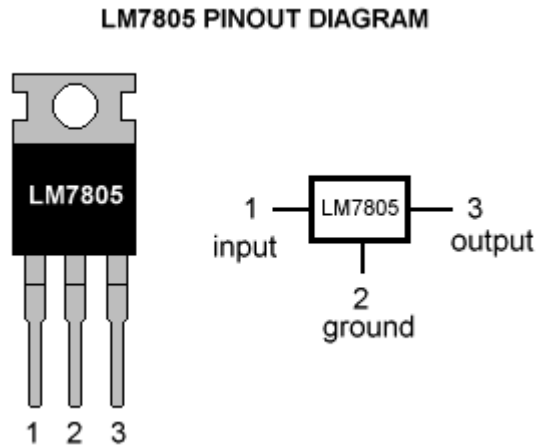


Figure 3.9: Pin configuration of IC 7805

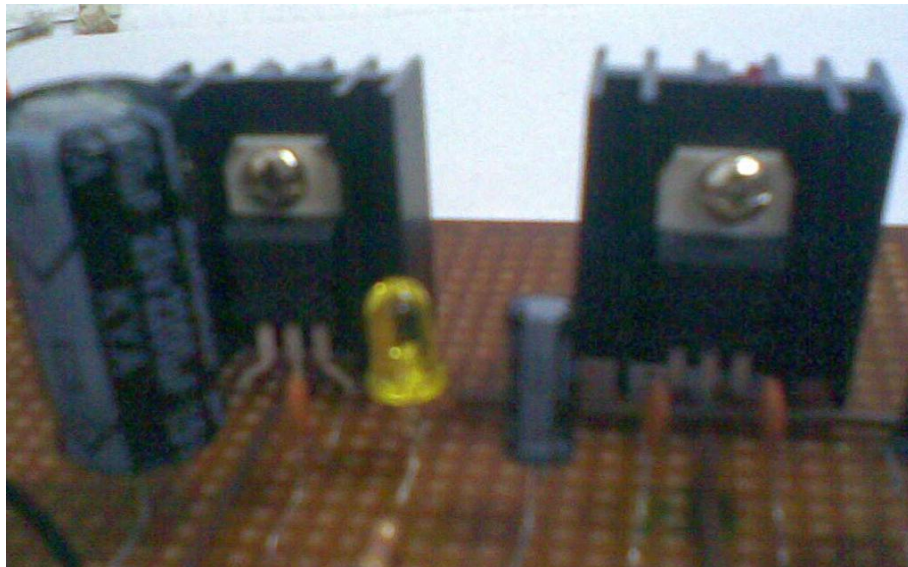


Figure 3.10: IC 7812 (left) and IC 7805 (right) respectively

3.4.3 Motor driver, L293D

If a DC motor is connected directly to the voltage supply, the constant power will be supplied to the DC motor all the time. Due to the constant power to motor, the speed

of motor will slow down when the load is heavier and speed up when the load is lighter. Therefore, DC motor drive is needed where we can control the magnitude of supply voltage in order to control the speed of DC motor when no load is changed.

The DC motor drive that will be used in this project is a dual full bridge driver, chip L293D as shown in Figure 3.11. The operating supply voltage of chip L293D is up to 46V and the total DC current up to 4A. The time to enable the chip L293D will be determined by the duty cycle pulse that sent from PWM in microcontroller.

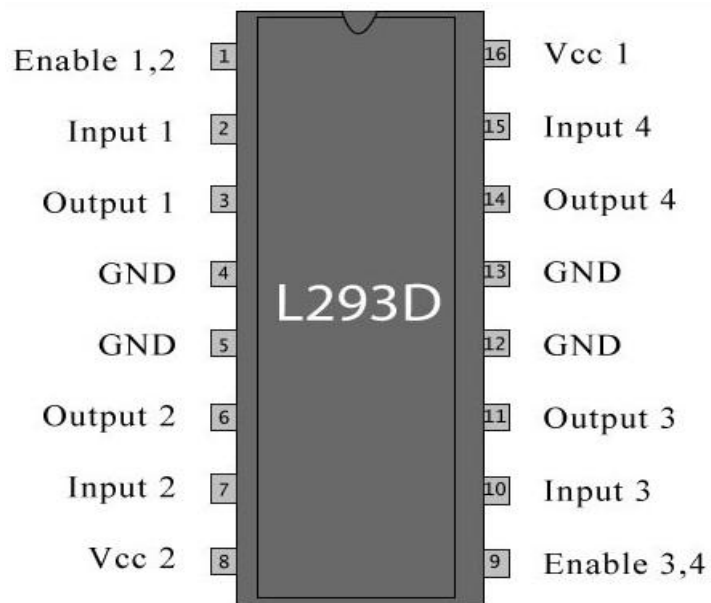


Figure 3.11: L293D with its pin configuration

Table 3.2 below shows the pin connection of chip L293D either from microcontroller PIC18F4550 or to DC motor.

Table 3.2: Pin connection of L293D motor driver

Name	Pin No.	Function
Enabled 1	1	Input PWM from PIC CCP1 pin 17
Input 1	2	Input data from PIC RD0 pin 19
Output 1	3	Connected to motor
Ground	4, 5, 13 & 12	Ground reference
Output 2	6	Connected to motor
Input 2	7	Input data from PIC RD1 pin 20
Supply voltage for motor, V_s	8	Power supply to motor
Vcc	16	Power supply for motor driver
Others	9, 10, 11, 14, 15	Not used

3.4.4 Microcontroller PIC18F4550

Microcontroller used in this project to control both speed and direction of DC motor is PIC18F4550 as shown in Figure 3.12. It is selected for this project due to its abundant online information and also among technician and ‘JP’ (Jurutera Pengajar), easily available (near, cash and carry), low cost and ease of use.



Figure 3.12: PIC18F4550

Table 3 below shows the pin connection of PIC18F4550 to other components in the system. Pins that not stated in the table are not used and left hanging.

Table 3: Pin connection of PIC18F4550 in the system

Pin Name	Pin No.	Description	Application
MCLR	1	Reset input	Connect to +5V
OSC1	13	For oscillator or resonator	Connected to resonator 20Mhz with 10nF
OSC2	14		
CCP1	17	PWM channel	Output of PWM duty cycle to control DC motor
RD0, RD1	19 & 20	Output pin	Output to control DC motor
RE1, RD2 – RD7	9, 21, 22, 27, 28, 29, 30	Output pin	Data output to LCD display
RB0, RB1	33, 34	Input pin	Connected to push button (speed command)
RB5 – RB7	38 - 40	Input pin	Connected to push button (direction command)
VDD	11 & 32	Positive supply 5V	Power supply to chip
VSS	12 & 31	Ground reference	Ground reference

3.4.5 USB Programmer, UP00B

A programmer is needed to burn the programmed that has built using compiler software into microcontroller. USB programmer used to burn the program is UP00B as shown in Figure 3.13. UP00B is the enhanced version of UP00A. As PIC MCU is

gaining its popularity in market for student and hobbyist, more low cost and user friendly programmer is needed. Previous USB PIC Programmer, UP00A is obsolete because it cannot support Windows Vista, fail to program many new PIC MCU, further the firmware is not upgradeable. Hence, UP00B is now introduced. It comes with two ZIP sockets to offer program loading to 8 pin, 18 pin, 28 pin and 40 pin PIC MCU (8 bit) by using Microchip PICKit2 software. It offers a low cost yet convenience USB PIC Programmer to user. UP00B are compatible for Window XP and Vista.



Figure 3.13: UP00B

3.5 Incorporating software into hardware

In this section, it shows the step taken to incorporate the software into hardware. It is explain briefly by flow chart in Figure 3.14 below.

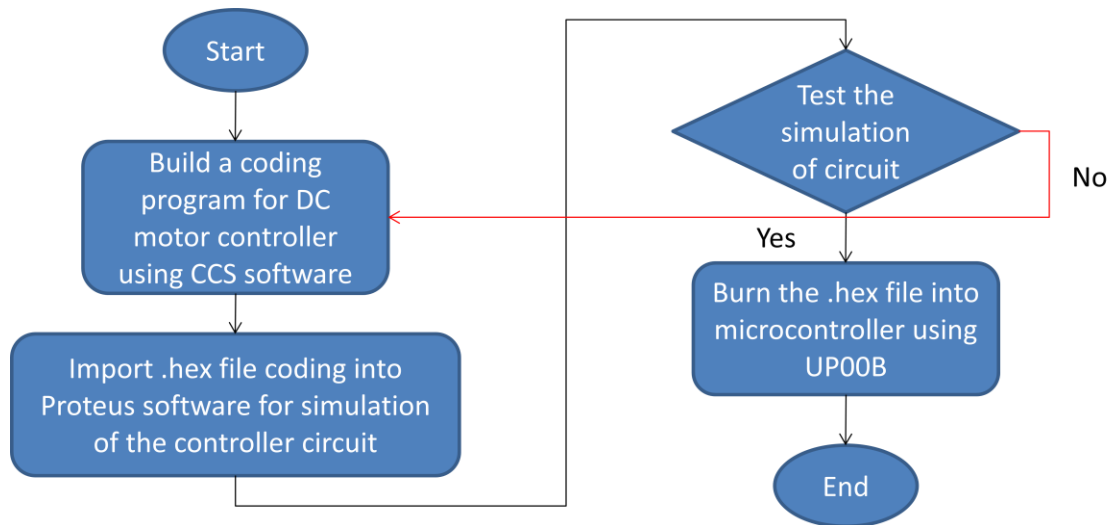


Figure 3.14: Incorporate control software into control hardware

CHAPTER 4

RESULT

4.1 Introduction

In this section, both simulation and experimental result are presented and discussed. The discussion focuses on the speed control and direction of DC motor.

4.2 Simulation result

4.2.1 Direction control

This section is discussed the direction control method of DC motor. Based on Figure 4.1 and Figure 4.2, digital oscilloscope shows the PWM signals when simulation

is carried out. The blue line represents the PWM signal that is generate by PIC18F4550 microcontroller. Besides that, the red line indicates the motor are in forward direction while the green line indicates the DC motor is in reverse direction. Other than that, the port signal of oscilloscope is not used which is the yellow line.

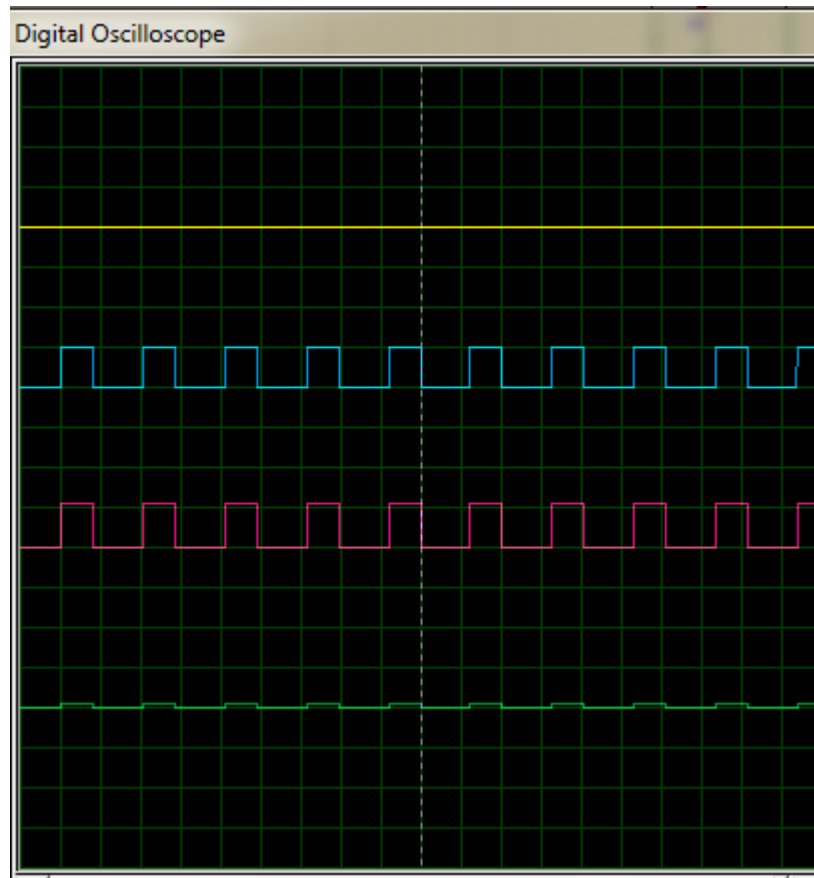


Figure 4.1: DC motor in forward condition

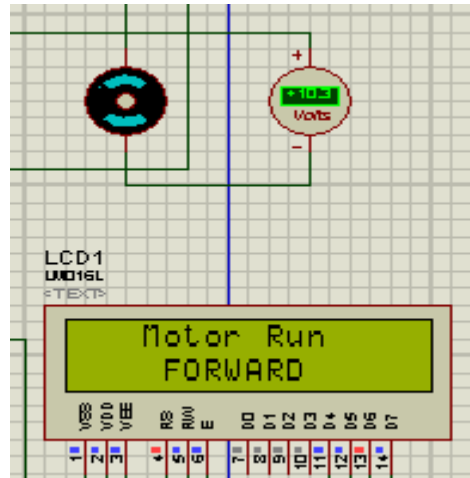


Figure 4.2: LCD indicator show the motor is run forward

Figure 4.1 show the DC motor is in forward condition. This is because the red line has the input of PWM signal instead of green line. Based on the Figure 4.2, the voltmeter gives value of +10.3V represent the direction of DC motor which are in forward condition. Besides that, LCD indicator will display “Motor Run FORWARD” to give indicator to user about DC motor condition when the reverse button is pressed.

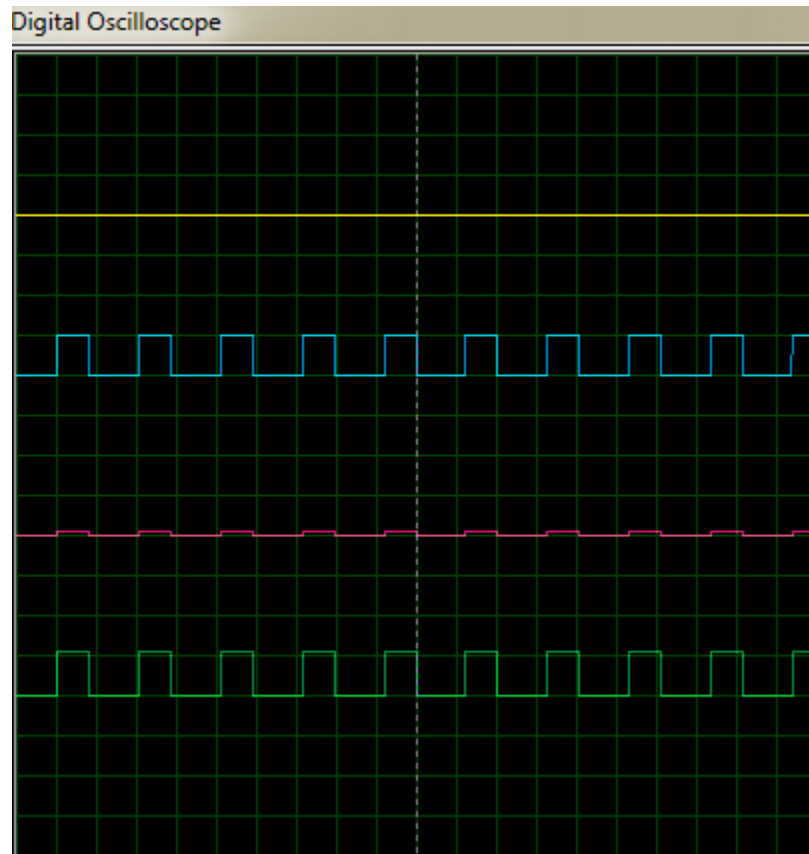


Figure 4.3: DC motor in reverse condition

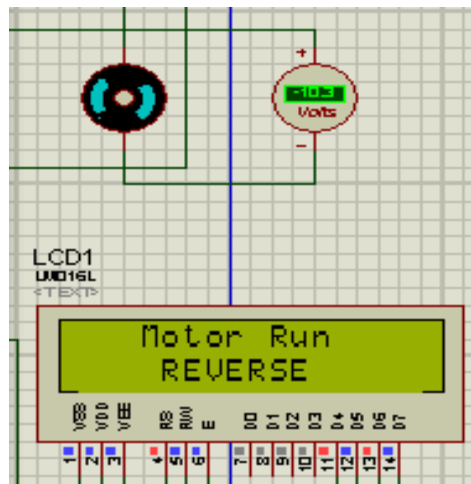


Figure 4.4: LCD indicator show the motor is run reverse

Figure 4.3 show the Dc motor is in reverse condition. This is because the green line has the input of PWM signal instead of red line. Based on the Figure 4.4, the

voltmeter gives value of -10.3V represent the direction of DC motor which are in reverse condition. Besides that, LCD indicator will display “Motor Run REVERSE” to give indicator to user about DC motor condition when the reverse button is pressed.

4.2.2 Speed control

In this section, the method of controlling the speed of DC motor is discussed. The speed of DC motor can be varied by controlling the duty cycle of the PWM generates by PIC18F4550 microcontroller as explained in detail in section 3.3.4. If the duty of the pulse becomes wider, than the speed of DC motor will increase. While if the duty of the pulse becomes smaller, than the speed of DC motor will decreased. The duty of pulse will be increase or decrease by 50 when each time button is pressed.

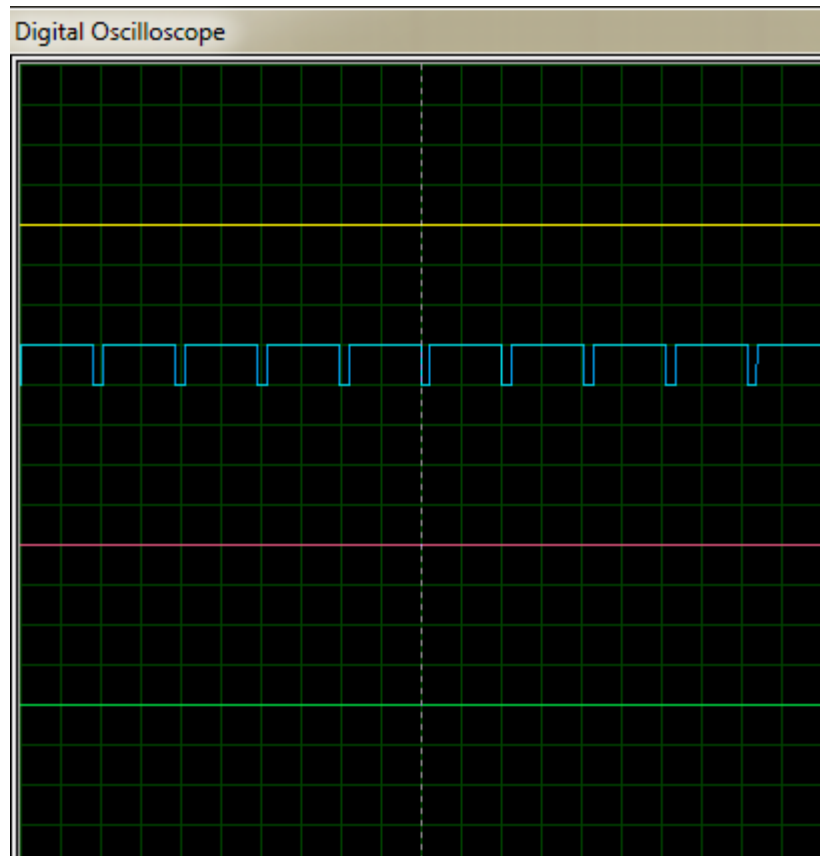


Figure 4.5: Initial condition

Figure 4.5 above show the initial condition when the simulation is executed. Only the PWM signal generated is detect by digital oscilloscope which represent by the blue line.

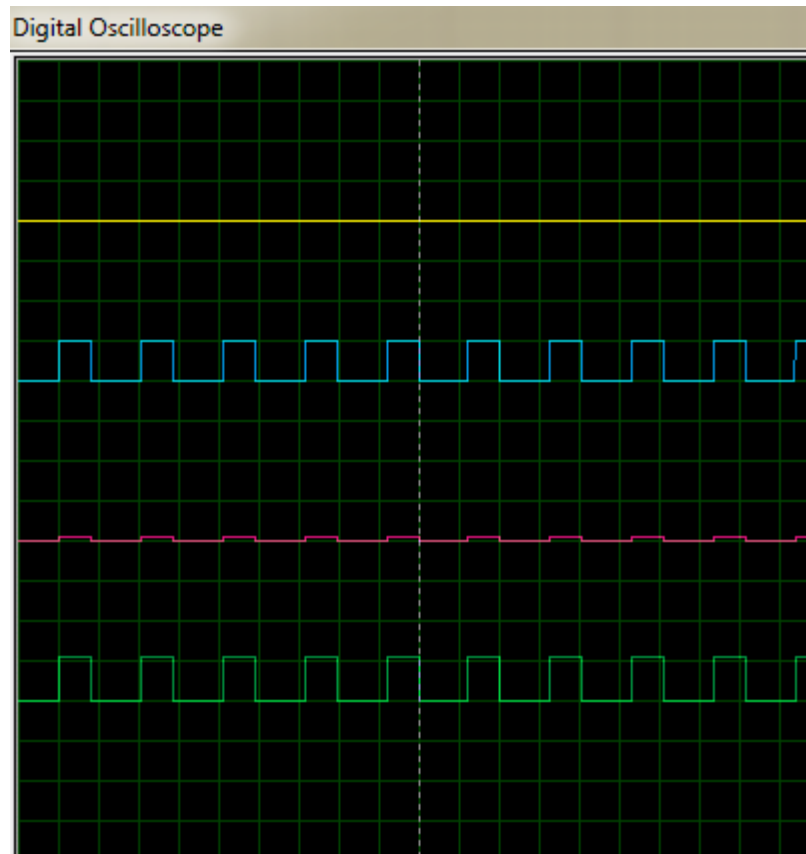


Figure 4.6: Speed of DC motor by duty cycle of 100

Figure 4.6 above show the condition of motor when the reverse push button is pressed. The initial speed detected by digital oscilloscope by showing the pulse signal width is 100. This speed is obtained by put the value in the PIC18F4550 microcontroller fixedly. The DC motor can also start by pressing the forward push button instead of reverse. The result of DC motor's speed is still same which either increased or decreased. The only different is the DC motor operates or run in forward or reverses direction.

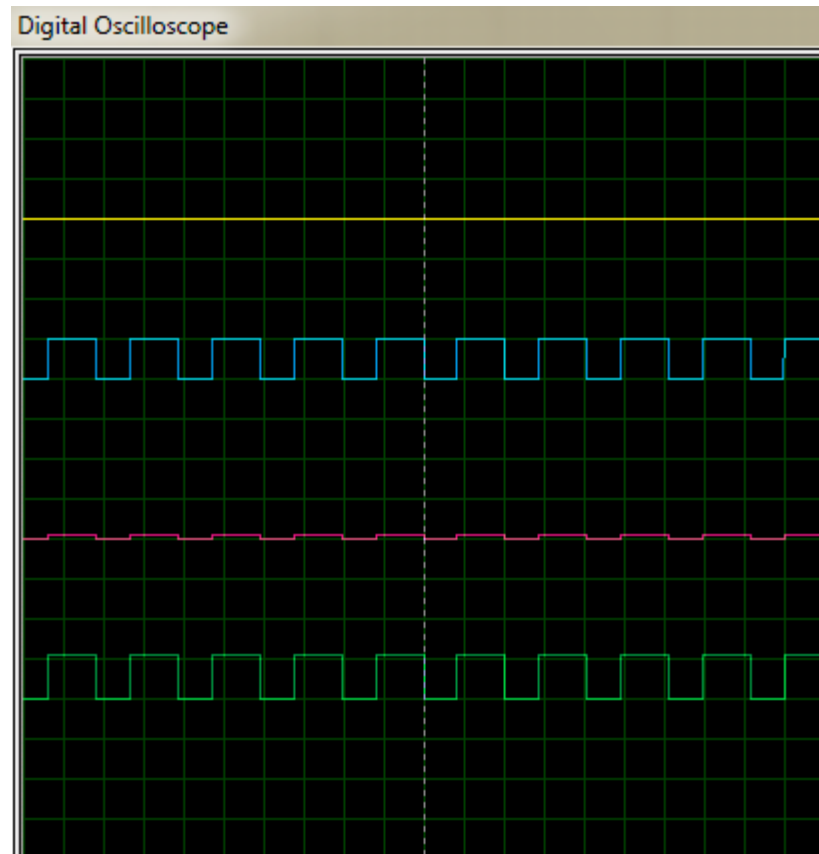


Figure 4.7: Speed of DC motor by duty cycle of 150

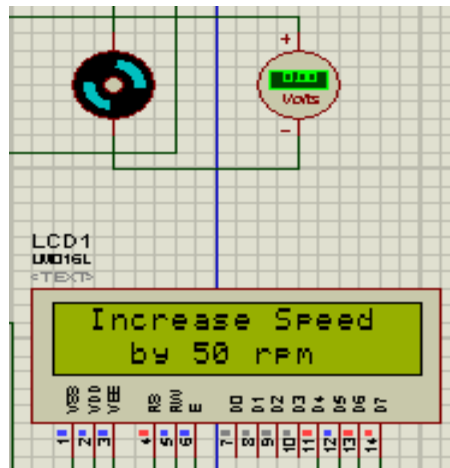


Figure 4.8: LCD indicator show the speed of DC motor is increased

Based on Figure 4.7 above, the digital oscilloscope shows the duty cycle of PWM becomes bigger than before by 50 after push button for increasing speed is pressed. By that, it shows the DC motor' speed is now increased. LCD indicator will

display “increase speed by 50 rpm” to inform user about condition of DC motor which is now increasing its speed.

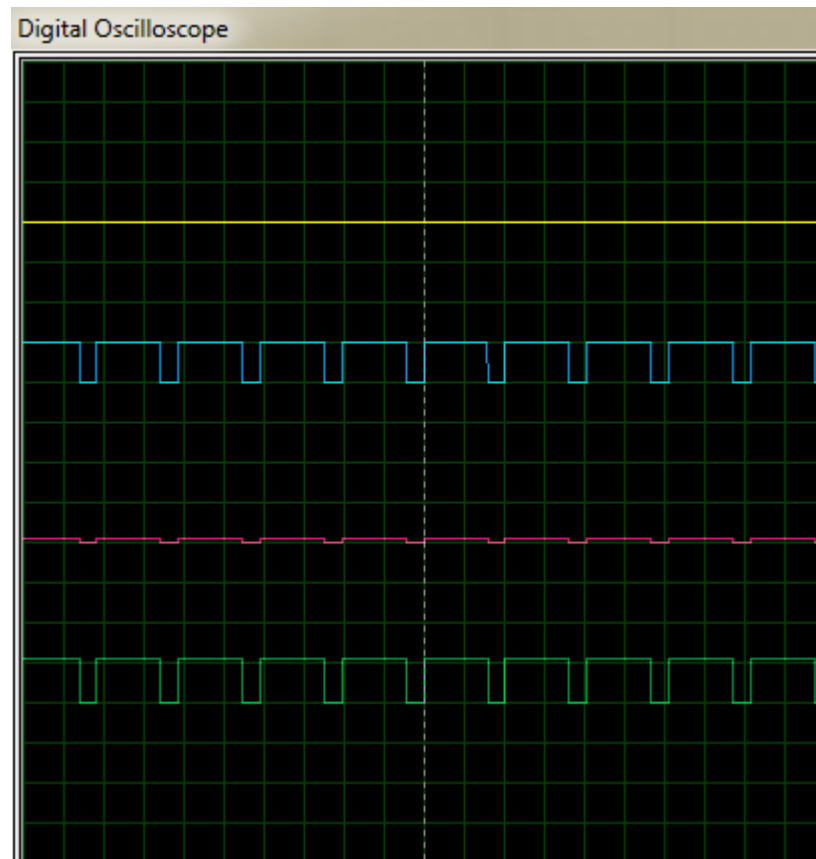


Figure 4.9: Speed of DC motor by duty cycle of 200

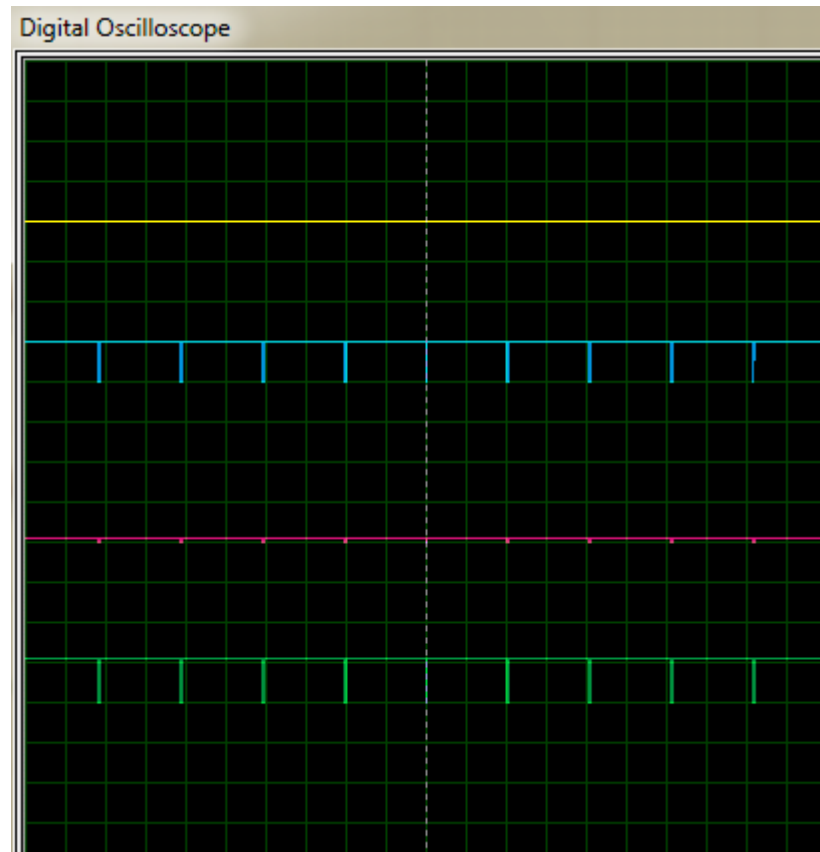


Figure 4.10: Speed of DC motor by duty cycle of 250

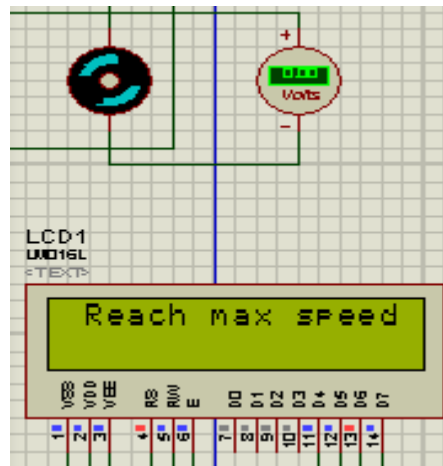


Figure 4.11: LCD indicator show the speed of DC motor is in maximum speed

Each time push button is pressed, the DC motor's speed will increased by 50. Both Figure 4.10 and Figure 4.11 show the increasing of DC motor's speed which is 200 and 250 respectively. LCD also will display the same as shown in Figure 4.11. But for

speed at duty cycle of 250, the LCD indicator will display “Reach max speed” where the DC motor already achieved maximum speed although the motor full speed can be achieved by PWM duty cycle of 255. It is also as a precaution to avoid the DC motor from overheating due to heavy workout.

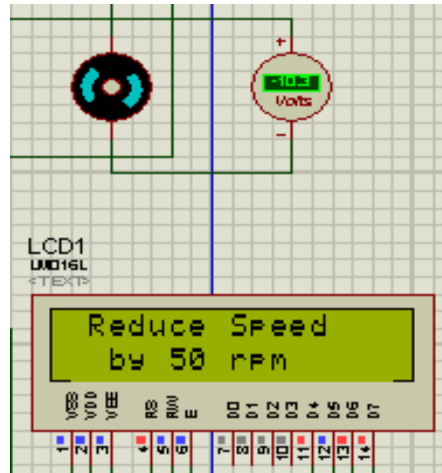


Figure 4.12: LCD indicator show the speed of DC motor is decreased

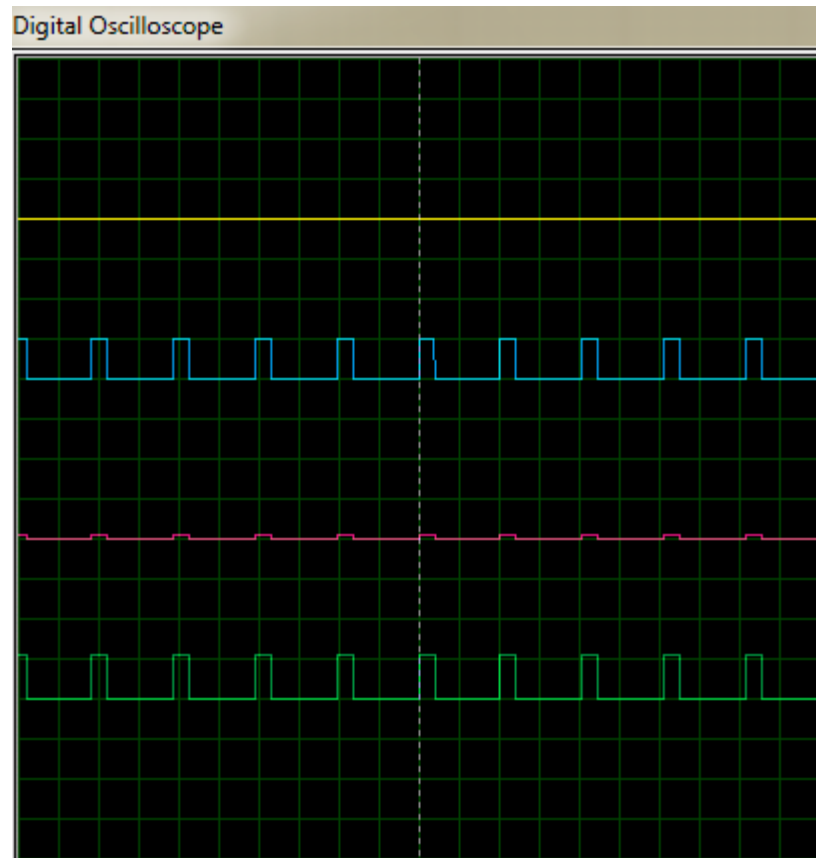


Figure 4.13: Speed of DC motor by duty cycle of 50

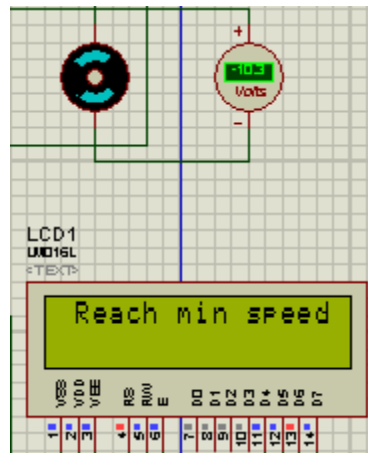


Figure 4.14: LCD indicator show the speed of DC motor is in minimum speed

For decreasing the speed of DC motor, push button for reducing speed need to be pressed. By that, the speed of DC motor also will be decreased as the duty cycle of PWM signal decreased by 50. The pulse signal will become smaller or narrower

showing the decreasing of DC motor's speed. For this condition also will be show by LCD as an indicator for DC motor's speed as shown in Figure 4.12. In Figure 4.13, it shows the minimum speed of DC motor that can be operating which is 50 rpm. This is to prevent the DC motor from stop operating due to no PWM signal input which is 0. Besides that, LCD indicator also will show "Reach min speed" to represent the DC motor condition as shown in Figure 4.14.

4.3 Experimental result

4.3.1 Direction control

In experimental testing, for direction control, light emitting diode or LED is used to detect the DC motor's direction. LED will be used in the circuit to see the flow of the current that makes the LED light up. The LEDs will indicate which way or direction is the DC motor rotates. The Figure 4.15 shows the DC motor is in initial condition. When the power supply is switched on, the current will flow through the circuit and LED. If the DC motor runs in forward direction, LED 1 will light up as show in Figure 4.16. While if the DC motor run in reverse direction, LED 2 will light up as show in Figure 4.17 below.



Figure 4.15: DC motor in initial condition

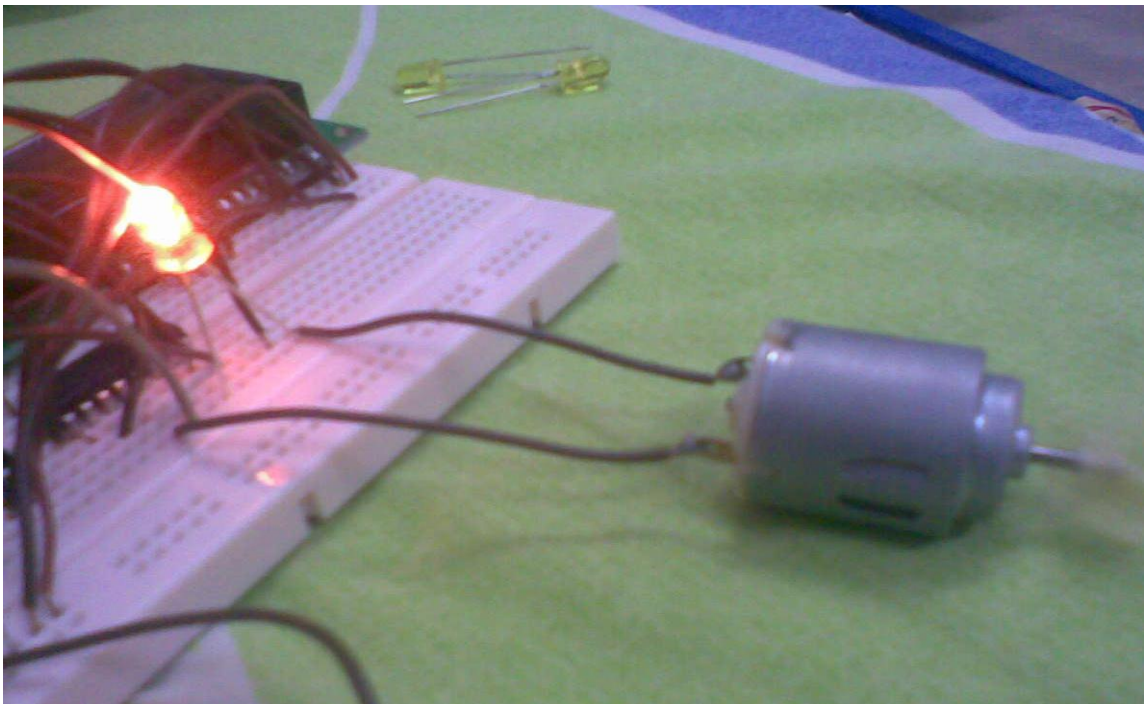


Figure 4.16: DC motor in forward direction

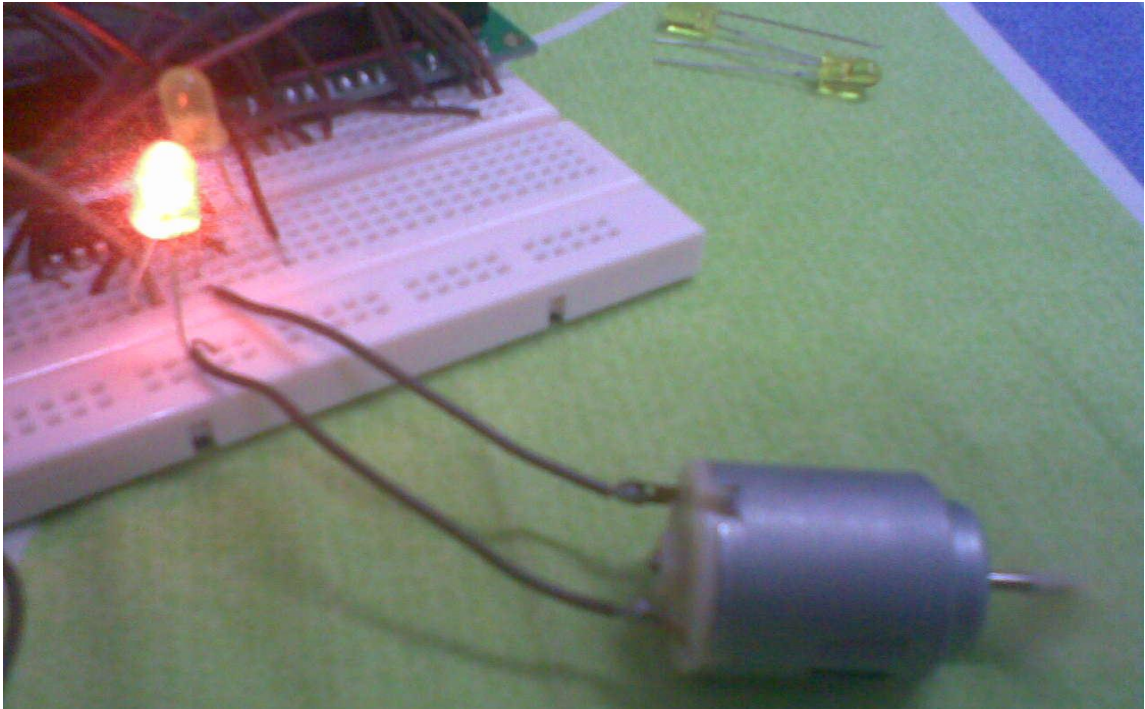


Figure 4.17: DC motor in reverse direction

4.3.2 Speed control

For speed control, the waveform of PWM pulse is shown from the oscilloscope at pin 17 of microcontroller. The pulses obtained are generated by the coding program that is build from the PIC C Compiler software. The result obtained shows the PWM waveform generated from microcontroller with different speed in term of width or duty cycle.

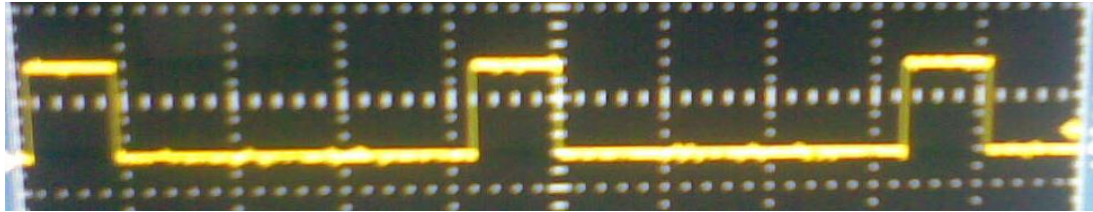


Figure 4.18: PWM waveform at $D = 19.61\%$

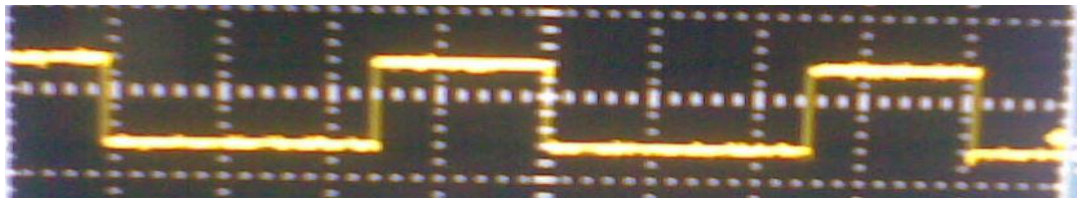


Figure 4.19: PWM waveform at $D = 39.22\%$

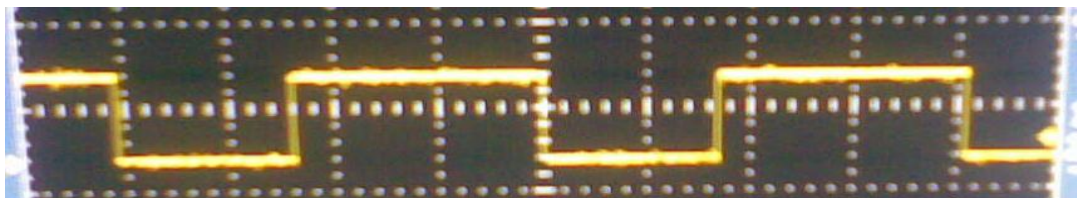


Figure 4.20: PWM waveform at $D = 58.82\%$



Figure 4.21: PWM waveform at $D = 78.43\%$

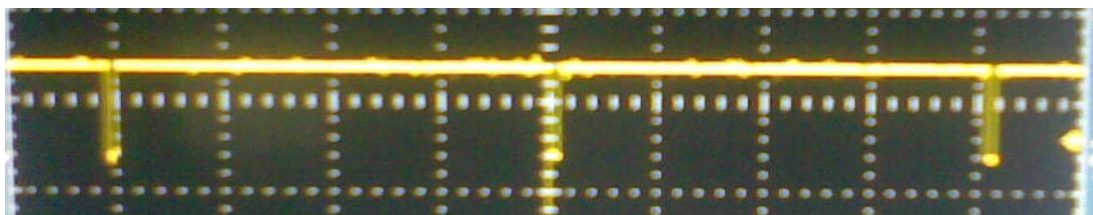


Figure 4.22: PWM waveform at $D = 98.04\%$

The result obtained show that the PWM width is varied by increasing of 50 where the duty ratio of the pulses is stated above. By controlling the period or width of PWM signal, the speed of DC motor can be controlled. The speed of DC motor will decreased if the duty cycle of the pulse becomes smaller. While speed of DC motor is increased as the duty pulse becomes bigger. By the Figure of 4.18, 4.19, 4.20, 4.21 and 4.22, the PWM waveform generated is in the increasing order of speed.

The DC motor's will run faster at $D = 78.43\%$ than at $D = 39.22\%$. At $D = 19.61\%$ is where the DC motor run at the lowest speed. At $D = 98.04\%$ is where the DC motor run at the fastest speed. The experimental result obtained is uniform with the simulation result. By comparing the experimental result with the simulation result, the result obtained can be verified to be correct.

There are a little bit problems with the hardware circuit. The motor did not work out after implement the circuit into the board after successfully testing on the breadboard. The problem can be L293D motor driver not the PIC18F4550 or the DC motor. This is because for PIC18F4550 microcontroller, it already generated the PWM pulse signals that given to the motor driver, L293D. the pulses can seen in the experimental result section. It is not the PMDC motor problem because it can rotate or run if +12V given directly to it. So the detected device problem is the motor driver. It is may due to over current that lead to internal damage of the driver because all the connection is correct and the signal given by PIC18F4550 is already given to pin 1 of motor driver.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Nowadays, science and technology field has been rapidly growing. It provides a wide range scope of applications of high performance DC motor drives. It can be seen in factories where machines are used such as rolling mills, cranes and even in home where electrical appliances are used. All of that requires speed controllers to perform task correctly without any accident. DC motors have speed control capabilities where speed, torque and direction of its rotation can be changed to meet new condition.

The aim of this project is to design and implement a system to control both DC motor's speed and direction using microcontroller. This system will be able to control the motor at desired speed using PWM technique. Besides that, the motor can be rotated either in forward or reverse direction.

In conclusion, the objective is not fully achieved due to some problems in hardware circuit but in simulation stage, it is successfully executed.

5.2 Problems

There are several problems occur during completion of this project. The problems with component delay the performance of the circuit. Always have to change with a good one. The minimum preparation of equipment also affect in perform the task properly and efficiently. Besides that, for the controller circuit, due to its open loop system, it is hard to measure the exact speed of DC motor.

5.3 Recommendation

The performance of the system is slightly sluggish. For some future works, some recommendation have been listed based on the problems in order to improve the system's performance becomes better and better.

- I. Make the system a feedback loop control by using sensor or optical encoder so that the measurement of speed can be more precise.
- II Use fuzzy logic idea in microcontroller to obtain a DC motor speed control system with excellent regulation and robustness.
- III Prepare many types of equipment for PSM student to ease them in completing their task without delay.

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3. Ea Ai Choon. *DC motor speed control using microcontroller PIC16F877A*. Bachelor's Degree, Universiti Teknologi Malaysia, Skudai; 2005.
4. <http://www.microchip.com>
5. <http://en.wikipedia.org/wiki/H-bridge>
6. http://www.mabuchi-motor.co.jp/cgi-bin/catalog/e_catalog.cgi?CAT_ID=rk_370ca
7. <http://www.wiringdiagrams21.com/2009/09/permanent-magnet-dc-motor-equivalent-circuit-diagram>

APPENDICES

Appendix A

```

#include <18F4550.h> // PIC18F4550 HEADER FILE
#fuses XT,NOWDT,NOLVP,NOPROTECT // EXTERNAL CLOCK, NO WATCH
DOG TIMER, NO LOW VOLTAGE
#define FORWARD PIN_B5 // FORWARD BUTTON
#define REVERSE PIN_B6 // REVERSE BUTTON
#define STOP PIN_B7 // STOP BUTTON
#define PWM_MOTOR PIN_C2 // PWM FOR MOTOR
#define MOTOR_FOR PIN_D0 // MOTOR FORWARD
#define MOTOR_REV PIN_D1 // MOTOR REVERSE
#define SPEED_INC PIN_B0
#define SPEED_DEC PIN_B1
#define LCD_ENABLE_PIN PIN_E1
#define LCD_RS_PIN    PIN_D2
#define LCD_RW_PIN    PIN_D3
#define LCD_DATA4     PIN_D4
#define LCD_DATA5     PIN_D5
#define LCD_DATA6     PIN_D6
#define LCD_DATA7     PIN_D7
#use delay(CLOCK = 4M)
#include <lcd.c>

unsigned int duty=50;
void main()
{

set_tris_b(0xFF); // SET ALL PORT B AS INPUT PORT
set_tris_d(0x00); // SET ALL PORT D AS OUTPUT PORT
set_tris_e(0x00);

```

```

output_b(0xFF); // RESET PORT B
output_d(0x00); // RESET PORT D
output_e(0x00);
setup_timer_2(T2_DIV_BY_4,254,1); //PWM 1 OUTPUT CONFIGURATION
setup_ccp1(ccp_pwm); //PWM 1 DUTY CYCLE CONFIGURATION
lcd_init();

{
  lcd_putc("\f Welcome to PSM2");
  lcd_putc("\n  Fatinah AG");
  delay_ms(200);
  lcd_putc("\fDC Motor Controlled");
  lcd_putc("\n  Based on mC");
}

while(TRUE) // always repeat program

{
  if (!input(FORWARD)) // when button forward press
  {
    output_high(MOTOR_FOR); // motor forward
    output_low(MOTOR_REV); // motor forward
    duty = 100; //set duty to 100
    set_pwm1_duty(duty); // pwm duty cycle value
    delay_ms(100);
    lcd_putc("\f  Motor Run");
    lcd_putc("\n  FORWARD");
  }
  else if (!input(REVERSE)) // when button reverse press
  {
    output_low(MOTOR_FOR); // motor reverse

```



```

output_high(MOTOR_REV); // motor reverse
duty = 100; //set duty to 100
set_pwm1_duty(duty); // pwm duty cycle value
delay_ms(100);
lcd_putc("\f Motor Run");
lcd_putc("\n REVERSE");
}
else if (!input(STOP)) // when button stop press
{
output_high(MOTOR_FOR); // motor stop
output_high(MOTOR_REV); // motor stop
duty = 0; //set duty to 100
set_pwm1_duty(duty); // pwm duty cycle value
delay_ms(100);
lcd_putc("\f Motor STOP");
}
if (!input(PIN_B0) && duty < 250)
{
duty = duty + 50;
set_pwm1_duty(duty);
delay_ms(100);
lcd_putc("\f Increase Speed");
lcd_putc("\n by 50 rpm");
if (duty==250)
{
lcd_putc("\f Reach max speed");
}
}
if(!input(PIN_B1) && duty > 50)
{
duty = duty - 50;

```

```
set_pwm1_duty(duty);  
delay_ms(100);  
lcd_putc("\f Reduce Speed");  
lcd_putc("\n  by 50 rpm");  
if (duty==50)  
{  
  lcd_putc("\f Reach min speed");  
}  
}  
}
```

Appendix B : Datasheet of DC motor

**RK-370CA**

OUTPUT:0.5W-24W (APPROX)

MABUCHI MOTOR
 Carbon-brush motors

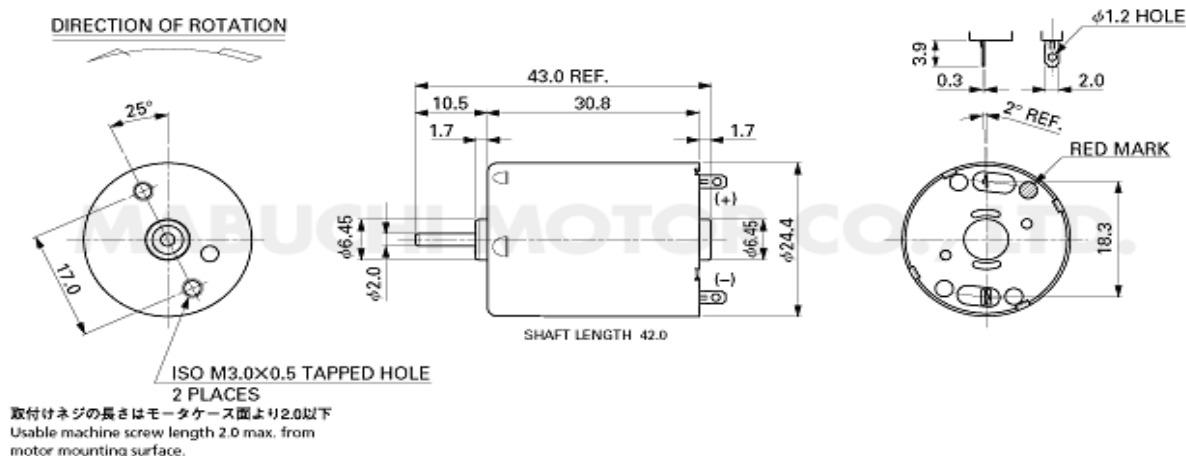

WEIGHT: 51g (APPROX)

Typical Applications : Home Appliances

Precision Instruments> Printer / Copy Machine / Laser Printer/Vending Machine

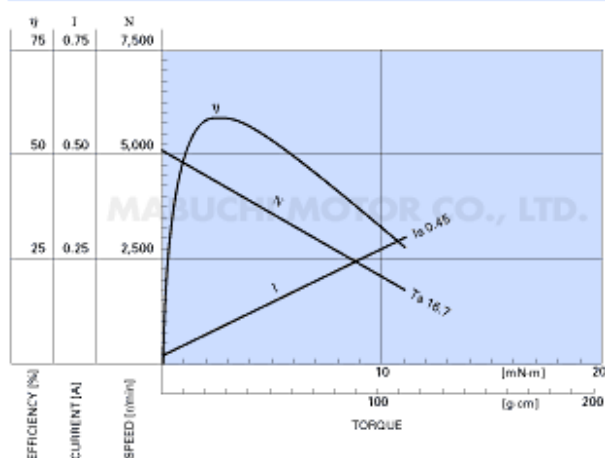
*By clicking the "MODEL", you can display the Performance Chart Simulation.

MODEL	VOLTAGE			NO LOAD		AT MAXIMUM EFFICIENCY				STALL		
	OPERATING RANGE	NOMINAL	SPEED	CURRENT		SPEED	CURRENT	TORQUE	OUTPUT	TORQUE	CURRENT	
RK-370CA	10800	12 - 30	24	5100	0.015	4310	0.082	2.58	26.3	1.16	16.7	170
	15370	12 - 24	12	5500	0.032	4690	0.19	2.71	27.7	1.33	18.4	188
	081050	12 - 30	24	3900	0.010	3210	0.047	1.90	19.3	0.64	10.8	110



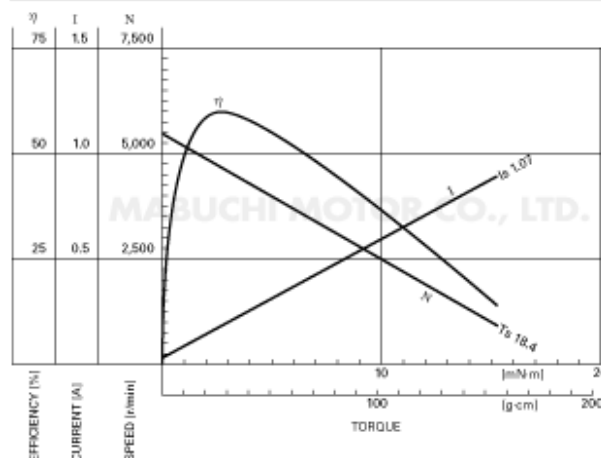
RK-370CA-10800

24.0V

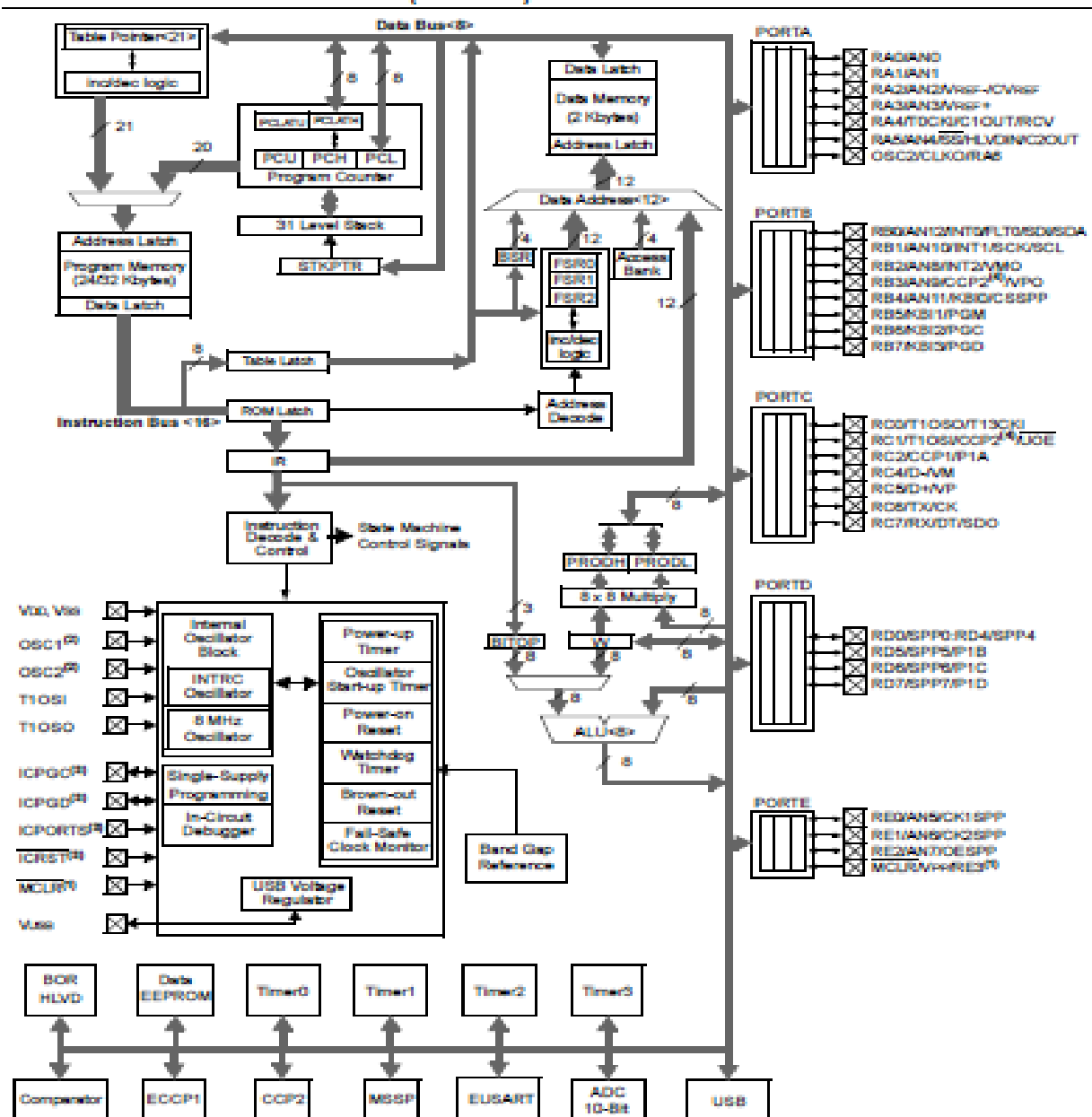


RK-370CA-15370

12.0V



Appendix C : Block diagram of PIC18F4550

PIC18F2455/2550/4455/4550**FIGURE 1-2: PIC18F4455/4550 (40/44-PIN) BLOCK DIAGRAM**

- Note 1: RE3 is multiplexed with MCLR and is only available when the MCLR Resets are disabled.
- Note 2: OSC1/MCLK and OSC2/CLKD are only available in select oscillator modes and when these pins are not being used as digital I/O. Refer to Section 2.9 "Oscillator Configurations" for additional information.
- Note 3: These pins are only available on 44-pin TQFP packages under certain conditions. Refer to Section 25.9 "Special IC/PORT Features (44-Pin TQFP Package Only)" for additional information.
- Note 4: RB3 is the alternate pin for CCP2 multiplexing.