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JUDUL: **DIRECT CURRENT MOTOR CONTROL LED BY MICROCONTROLLER CREATED PWM**

SESI PENGAJIAN: 2011/2012

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DIRECT CURRENT MOTOR CONTROL LED BY MICROCONTROLLER CREATED PWM

THINESH A/L KUNASEGERAN

Thesis submitted in fulfillment of the requirements

for the award of the degree of

Bachelor of Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI MALAYSIA PAHANG

JUNE 2012

SUPERVISOR'S DECLARATION

"I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of Degree of Bachelor of Manufacturing Engineering (Manufacturing)"

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I hereby declare that this thesis entitled "Direct Current Motor Control Led by Microcontroller Created PWM" is the results of my own research except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Special dedicated to my beloved parents

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ABSTRACT

Direct current (DC) motor has already become an important drive configuration for many applications across a wide range of powers and speeds. The ease of control and excellent performance of the DC motors will ensure that it is widely used in many applications. This project is mainly concerned on DC motor speed control system by using microcontroller PIC 16F877A. Pulse Width Modulation (PWM) technique is used where its signal is generated in microcontroller. The program for PWM generation is written in C+ Language using MPLAB IDE software. It is programmed into the microcontroller using PIC Microcontroller Start-up Kit. Then the microcontroller is installed into the motor control circuit. The Microcontroller acts as the motor speed controller in this project. The PWM signal will send to motor driver to vary the voltage supply to motor to acquire desired speed. Besides, it also shows a graph of motor speed versus PWM dutycycle percentage to let the user monitor the performance of the system easily. Based on the result, the readings are quite reliable. Through the project, it can be concluded that microcontroller PIC 16F877A can control motor speed at desired speed efficiently by using Pulse Width Modulation signal.

ABSTRAK

Motor arus terus telah menjadi satu komponen yang penting untuk aplikasi dalam julat kuasa dan kelajuan yang tinggi. Kawalan motor arus terus yang mudah dan prestasi yang baik akan menjamin motor arus terus untuk digunakan secara meluas. Projek ini tertumpu kepada rekaaan satu sistem kawalan kelajuan motor arus terus dengan menggunakan mikropengawal PIC 16F877A. Teknik *Pulse Width Modulation (PWM)* digunakan di mana isyarat ini dibekal oleh mikro pengawal. Program untuk penjanaan PWM ditulis dalam bahasa C+ dengan menggunakan perisian MPLAB IDE. Program itu dimuat-turun dalam mikropengawal menggunakan PIC Microcontroller Start-up Kit. Kemudian, mikropengawal tersebut dipasang pada 'cicuit' pengawal motor. Mikropengawal berperanan sebagai pengawal kelajuan motor di dalam projek ini. Isyarat *PWM* akan dihantar kepada pemacu motor untuk mengubah voltan yang dibekalkan kepada motor supaya ia dapat dikawal pada kelajuan yang diingini. Selain itu, ia juga memaparkan satu graf kelajuan motor melawan peratus 'dutycycle' PWM untuk membolehkan pengguna mengkaji prestasi sistem tersebut. Keputusan menunjukkan bahawa bacaan daripada eksperimen adalah boleh dipercayai. Melalui projek ini, boleh disimpulkan bahawa mikropengawal PIC 16F877A dapat mengawal kelajuan motor pada kelajuan diingini dengan menggunakan isyarat PWM.

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LIST OF ABBREVIATION

PWM	Pulse Width Modulation
DC	Direct Current
IR	Infra Red

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

DC motor plays a significant role in modern industrial. These are several types of applications where the load on the DC motor varies over a speed range. These applications may demand high-speed control accuracy and good dynamic responses. In home appliances, washers, dryers and compressors are good examples. In automotive, fuel pump control, electronic steering control, engine control and electric vehicle control are good examples of these. In aerospace, there are a number of applications, like centrifuges, pumps, robotic arm controls, gyroscope controls and so on. 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.

Adjustable speed drive or variable-speed drive describes the system of equipment used to control the speed of machinery. There are many industrial processes such as production lines must operate at different speeds for different products. By varying the speed of the drive, energy may save compared with other techniques for control systems.

Process control and energy conservation are the two primary reasons for using an adjustable speed drive. Historically, adjustable speed drives were developed for process control, but energy conservation has emerged as an equally important objective. The following are process control benefits that might be provided by an adjustable speed drive:

i. Smoother operation
ii. Acceleration control
iii. Different operating speed for each process recipe
iv. Compensate for changing process variables
v. Allow slow operation for setup purposes
vi. Adjust the rate of production
vii. Allow accurate positioning
viii. Control torque or tension

From research, I have found several ways to control the motor speed using electronic devices. There are included voltage speed control, field speed control (I field), resistance speed control and PWM technique. These control method have their benefit and disadvantages respectively which is more focus to efficiency element.

In this technology era, real world applications often call for controlling small to medium sized DC motors from digital circuits. For smaller motors it is usually economically infeasible to buy a commercial speed controller as the cost of the controller will far outstrip the cost of the motor itself. The PIC's high speed, low cost, and low power requirements lend it to being an inexpensive "smart chip" controller for DC motors. The concept of PIC operation is generating PWM to drive devices. It is very easy to control the speed of DC motor from zero to maximum speed. PWM generator can be applied as control signal thus reduces the losses energy.

1.2 PROBLEM STATEMENT

The most issues discusses in speed controller is regarding their efficiency and reliability. The efficiency element is important in order to save cost. The efficiency of speed controller is depending on method of control system. The speed controller usually controlled in analog system.

An analog signal has a continuously varying value, with infinite resolution in both time and magnitude. For example, a 5V is an analog and its output voltage is not precisely 5V, changes over time, and can take any real-numbered value. Similarly, the amount of current drawn from a battery is not limited to a finite set of possible values. Analog signals are distinguishable from digital signals because the latter always take values only from a finite set of predetermined possibilities.

As intuitive and simple as analog control may seem, it is not always economically attractive or otherwise practical. For one thing, analog circuits tend to drift over time and can, therefore, be very difficult to tune. Precision analog circuits, which solve that problem, can be very large, heavy, and expensive. There are weaknesses in analog system.

In a PWM circuit, common small potentiometers may be used to control a wide variety of loads in PWM generating circuit whereas large and expensive high power variable resistors are needed for resistive controllers. The simplest of PWM circuit is using 555 timers in mono stable operation and it not reliable for high voltage application. There are also may causes high loss, higher damage and others. This application is also not practical and not precise result.

Manual controller is also not practical in the technology era because it can waste time and cost. Operation cost regarding controller is got attention from industrial field. In order to reduce cost and time, we suggest making a controller based on computer because it is portable. The user can monitor their system at certain place without need to going the plant (machine) especially in industrial implementation. From that, the man power can be reduced and reserve with computer which is more precise and reliable.

The other product regarding this project where control motor via computer may be commercialized but their cost is very expensive. The hardware of this product may be complicated and maintenance cost is higher. The low cost electronic devices can be designed to make a speed controller system.

1.3 PROPOSED SOLUTION

Digital control is the better solution to overcome these problems. By controlling analog circuits digitally, system costs and power consumption can be drastically reduced. Many microcontrollers already include on-chip PWM controllers, making implementation easy.

One of the advantages of PWM is that the signal remains digital all the way from the processor to the controlled system which no digital-to-analog conversion is necessary. By keeping the signal digital, noise effects are minimized.

1.4 OBJECTIVES

i. To design a circuit to control speed of DC motor driven by PWM
ii. To built a programming coding in PIC in order to generate PWM to drive the circuit and DC motor

1.5 SCOPE OF PROJECT

In order to achieve the objective of the project, there are several scope had been outlined. The scope of this project includes using USB ICSP PIC Programmer, PIC Microcontroller Start-up Kit, and MPLAB IDE to program microcontroller to generate PWM signal; and building hardware for the DC motor control system.

1.6 THESIS OVERVIEW

This thesis is a combination of 5 chapters that contains the Introduction, Literature Review, Hardware & Software design, Result & Discussion and lastly Conclusion. .

Chapter 1 is the introduction of the project. The background, objective, problem statement and the scope of project are explained in this chapter.

Chapter 2 is the literature review that made from several journal that been refer and also consist of the methodologies to done the project.

Chapter 3 is the explanation of hardware and software design of the project. In hardware design, will be focusing on the construction of the DC motor control system. For software design, the programming of the PIC16F877A will be explained.

Chapter 4 will show all the results and the analysis of the project. All of the result obtain will be analyzed and the comment will be given due to the result getting.

For Chapter 5, the conclusion and recommendations will be discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

Conducting literature review prior to begin a research project is vital as this will supply the researcher with much needed additional and information on the methodologies and technology available used by other research counterparts around the world on the topic. This chapter provides a condensed summary of literature reviews on key topics related to DC motor control.

2.1 DC Motors

There are several types of DC motors that are available. Their advantages, disadvantages, and other basic information are listed below in the Table 2.1.

Table 2.0 Advantages and disadvantages of various types of DC motor.

Type	**Advantages**	**Disadvantages**
DC Geared Motor	Very precise speed and position control. High Torque at low speed.	Low speed. Mechanical wear and require regular servicing
DC Motor w/field coil	Wide range of speeds and torques. More powerful than permanent magnet motors	Require more current than permanent magnet motors, since field coil must be energized. Generally heavier than permanent magnet motors. More difficult to obtain.
DC permanent magnet motor	Small, compact, and easy to find. Very inexpensive	Generally small. Cannot vary magnetic field strength.
Gasoline (small two stroke)	Very high power/weight ratio. Provide Extremely high torque. No batteries required.	Expensive, loud, difficult to mount, very high vibration.

2.2 Speed Measurement by Using Tachometer

Tachometer is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are increasingly common.

Figure 2.0 Tachometer

2.3 PIC controller

2.3.1 Microcontroller

Microcontrollers contain at least two primary components – random access memory (RAM), and an instruction set. RAM is a type of internal logic unit that stores information temporarily. RAM contents disappear when the power is turned off. While RAM is used to hold any kind of data, some RAM is specialized, referred to as registers. The instruction set is a list of all commands and their corresponding functions. During operation, the microcontroller will step through a program (the firmware). Each valid instruction set and the matching internal hardware that differentiate one microcontroller from another.

Most microcontrollers also contain read-only memory (ROM), programmable read-only memory (PROM), or erasable programmable read-only memory (EPROM). Al1 of these memories are permanent: they retain what is programmed into them even during loss of power. They are used to store the firmware that tells the microcontroller how to operate. They are also used to store permanent lookup tables. Often these memories do not reside in the microcontroller; instead, they are contained in external ICs, and the instructions are fetched as the microcontroller runs. This enables quick and low-cost updates to the firmware by replacing the ROM.

The number of I/O pins per controllers varies greatly, each I/O pin can be programmed as an input or output (or even switch during the running of a program). The load (current draw) that each pin can drive is usually low. If the output is expected to be a heavy load, then it is essential to use a driver chip or transistor buffer. [9][10]

2.3.2 Types of Microcontroller

Microcontrollers PICmicro MCU from Microchip Company divided into 4 large families. Each family has a variety of components that provide built-in special features:

1. **The first family, PIC10 (10FXXX) - is called Low End.**

The PIC10FXXX devices from Microchip Technology are low-cost, high-performance, 8-bit, fully static, Flash-based CMOS microcontrollers. They employ a RISC architecture with only 33 single-word/ single-cycle instructions. The 12-bit wide instructions are highly symmetrical. The easy-to-use and easy to remember instruction set reduces development time significantly. The PIC10FXXX devices contain an 8-bit ALU and working register.

2. **The second family, PIC12 (PIC12FXXX)– is called Mid-Range.**

The PIC12FXXX most popular among these starter their way in this field. Mid-Range devices feature 14-bit program word architecture and are available in 8 to 64-pin packages that offer an operating voltage range of 1.8-5.5V, small package footprints, interrupt handling, an 8-level hardware stack, multiple A/D channels and EEPROM data memory. Mid-range devices offer a wide range of package options and a wide range of peripheral integration. These devices feature various serial analog and digital peripherals, such as: SPI, I2C™, USART, LCD and A/D converters.

3. **The third family is PIC16(16FXXX).**

With six variants ranging from 3.5K-14 Kbytes of Flash memory, up to 256 bytes of RAM and a mix of peripherals including EUSART, CCP and onboard analog comparators. These devices are well suited for designers with applications that need more code space or I/O than 14-pin variants supply, and are looking to increase system performance and code efficiency by employing hardware motor control and communications capability.

4. **The fourth family is PIC 17/18(18FXXX).**

The PIC18 family utilizes a 16-bit program word architecture and incorporates an advanced RISC architecture with 32 level-deep stack, 8x8 hardware multiplier, and multiple internal and external interrupts. With the highest performance in Microchip's 8-bit portfolio, the PIC18 family provides up to 16 MIPS and linear memory. PIC18 is the most popular architecture for new 8-bit designs where customers want to program in C language.

Table 2.0 List of the PIC controller type

PIC #	# of pins	I/O pins	Program ROM words	File RAM bytes	EEPROM bytes	Analogue inputs	Timers 8/16 bits	Max clock (MHz)	Internal osc. (MHz)	In-circuit debug	Serial comms
12F675	8	6	1k	64	128	4x10-bit	1/1	20	4	YES	NO
16F628A	18	16	2k	224	128	NO	2/1	20	4	NO	UART
16F630	14	12	1k	64	128	NO	1/1	20	4	YES	NO
16F648A	18	16	4k	256	256	NO	2/1	20	4	NO	UART
16F676	14	12	1k	64	128	8x10-bit	1/1	20	4	YES	UART
16F73	28	22	4k	192	NO	5x8-bit	2/1	20	NO	NO	ALL
16F77	40	33	8k	368	NO	8x8-bit	2/1	20	NO	NO	ALL
16F818	18	16	1k	128	128	5x10-bit	2/1	20	8	YES	I2C,SPI
16F84	18	13	1k	64	64	NO	1/0	10	NO	NO	NO
16F84A	18	13	1k	64	64	NO	1/0	20	NO	NO	NO
16F88	18	16	4k	368	256	7x10-bit	2/1	20	8	YES	ALL
16F874A	40	33	4k	192	128	8x10-bit	2/1	20	NO	YES	ALL
16F876A	28	22	8k	256	368	5x10-bit	2/1	20	NO	YES	ALL
16F877A	40	33	8k	256	368	8x10-bit	2/1	20	NO	YES	ALL
18F2320	28	25	4k	512	256	10x10-bit	1/3	40	8	YES	ALL
18F6520	64	52	16k	2048	1024	12x10-bit	1/3	40	NO	YES	ALL
18F8621	80	68	32k	3840	1024	16x8-bit	1/3	40	10	YES	I2C,SPI
18F8720	80	68	64k	3840	1024	16x10-bit	1/3	40	NO	YES	ALL

2.4 Control System

Control theory is an interdisciplinary branch of engineering and mathematics that deals with the behavior of dynamical systems .The desired output of a system is called the reference. When one or more output variables of a system need to follow a certain reference over time, a controller manipulates the inputs to a system to obtain the desired effect on the output of the system.

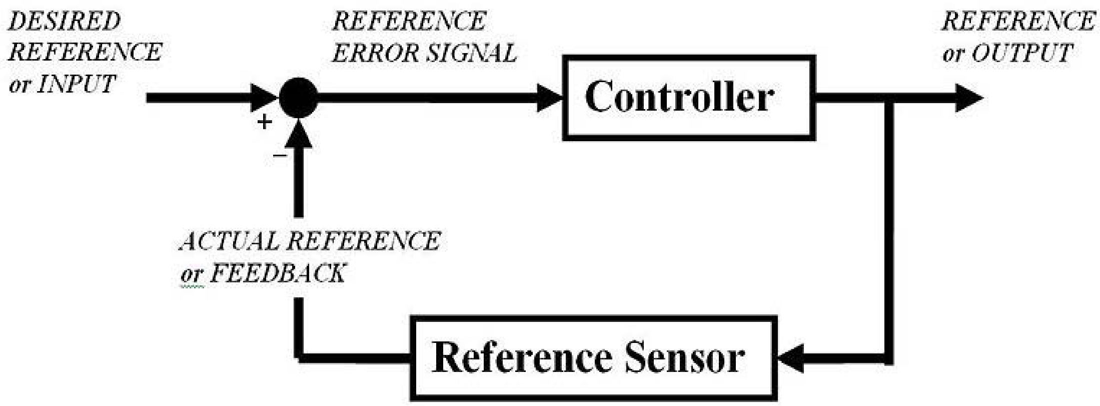

Figure 2.1 Concept of the Feedback Loop to Control the Dynamic Behavior of the

If we consider an automobile cruise control, it is design to maintain the speed of the vehicle at a constant speed set by the driver. In this case the system is the vehicle. The vehicle speed is the output and the control is the vehicle throttle which influences the engine torque output. One way to implement cruise control is by locking the throttle at the desired speed but when encounter a hill the vehicle will slow down going up and accelerate going down. In fact, any parameter different than what was assumed at design time will translate into a proportional error in the output velocity, including exact mass of the vehicle, wind resistance, and tire pressure .This type of controller is called an open-loop controller because there is no direct connection between the output of the system (the engine torque) and the actual conditions encountered mean the system does not and cannot compensate for unexpected forces.

For a closed-loop control system, a sensor will monitor the vehicle speed and feedback the data to its computer and continuously adjusting its control input or the throttle as needed to ensure the control error to a minimum therefore maintaining the desired speed of the vehicle. Feedback on how the system is actually performing allows the controller (vehicle's on board computer) to dynamically compensate for disturbances to the system, such as changes in slope of the ground or wind speed. An ideal feedback control system cancels out all errors, effectively mitigating the effects of any forces that may or may not arise during operation and producing a response in the system that perfectly matches the user's wishes.

2.5 Pulse Width Modulation (PWM)

Pulse Width Modulation (PWM) uses digital signals to control power applications, as well as being fairly easy to convert back to analog with a minimum of hardware.

Analog systems, such as linear power supplies, tend to generate a lot of heat since they are basically variable resistors carrying a lot of current. Digital systems don't generally generate as much heat. Almost all the heat generated by a switching device is during the transition (which is done quickly), while the device is neither on nor off, but in between. This is because power follows the following formula:

P = E I, or Watts = Voltage X Current

If either voltage or current is near zero then power will be near zero. PWM takes full advantage of this fact.

PWM can have many of the characteristics of an analog control system, in that the digital signal can be free wheeling. PWM does not have to capture data, although there are exceptions to this with higher end controllers.

Pulse-width modulation uses a square wave whose pulse width is modulated resulting in the variation of the average value of the waveform. If we consider a square waveform $f(t)$ with a low value *ymin*, a high value *ymax* and a duty cycle D (see figure 2.3), the average value of the waveform is given by:

$$\bar{y} = \frac{1}{T}\int_0^T f(t)\,dt.$$

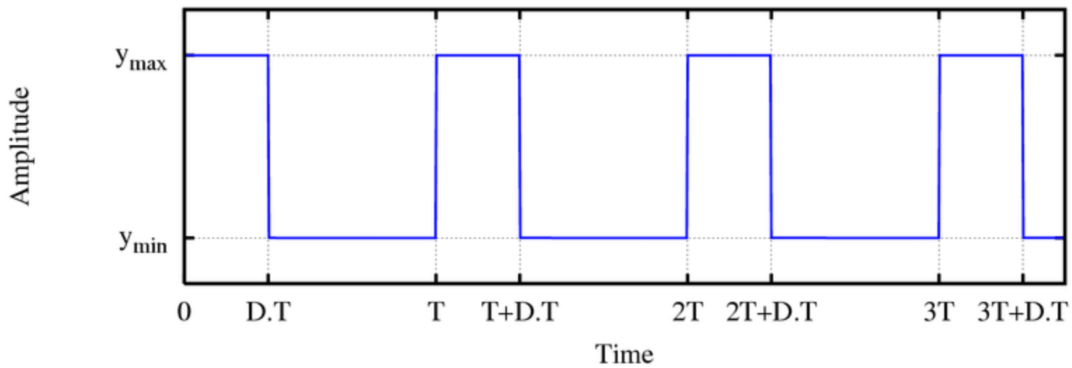

Figure 2.3: A Square Wave, Showing the Definitions of *ymin*, *ymax* and D

One of the parameters of any square wave is duty cycle. Most square waves are 50%, this is the norm when discussing them, but they don't have to be symmetrical. The ON time can be varied completely between signal being off to being fully on, 0% to 100%, and all ranges between.

Examples of a 10%, 50%, and 90% duty cycle in Figure 2.2. While the frequency is the same for each, this is not a requirement.

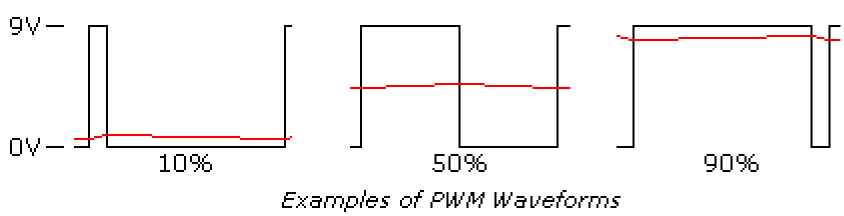

Figure 2.2 PWM examples of a 10%, 50%, and 90% duty cycle

The reason PWM is popular is simple. Many loads, such as resistors, integrate the power into a number matching the percentage. Conversion into its analog equivalent value is straightforward. Popular application of PWM is motor speed control. Motors as a class require very high currents to operate. Being able to vary their speed with PWM increases the efficiency of the total system by quite a bit. PWM is more effective at controlling motor speeds at low RPM than linear methods.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

In this project, microcontroller will be used as the controller to control DC motor speed at desired speed. The block diagram of the system is shown in Figure 3.1.

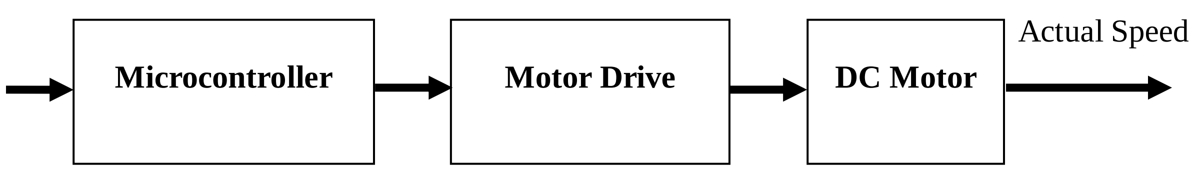

Figure 3.1: Block diagram for project

The actual speed of DC motor will be measured by tachometer. Microcontroller will determine duty cycle of pulse-width- modulation (PWM). Then, the duty cycle will send to DC motor driver either accelerate or decelerate DC motor to maintain it at desired speed.

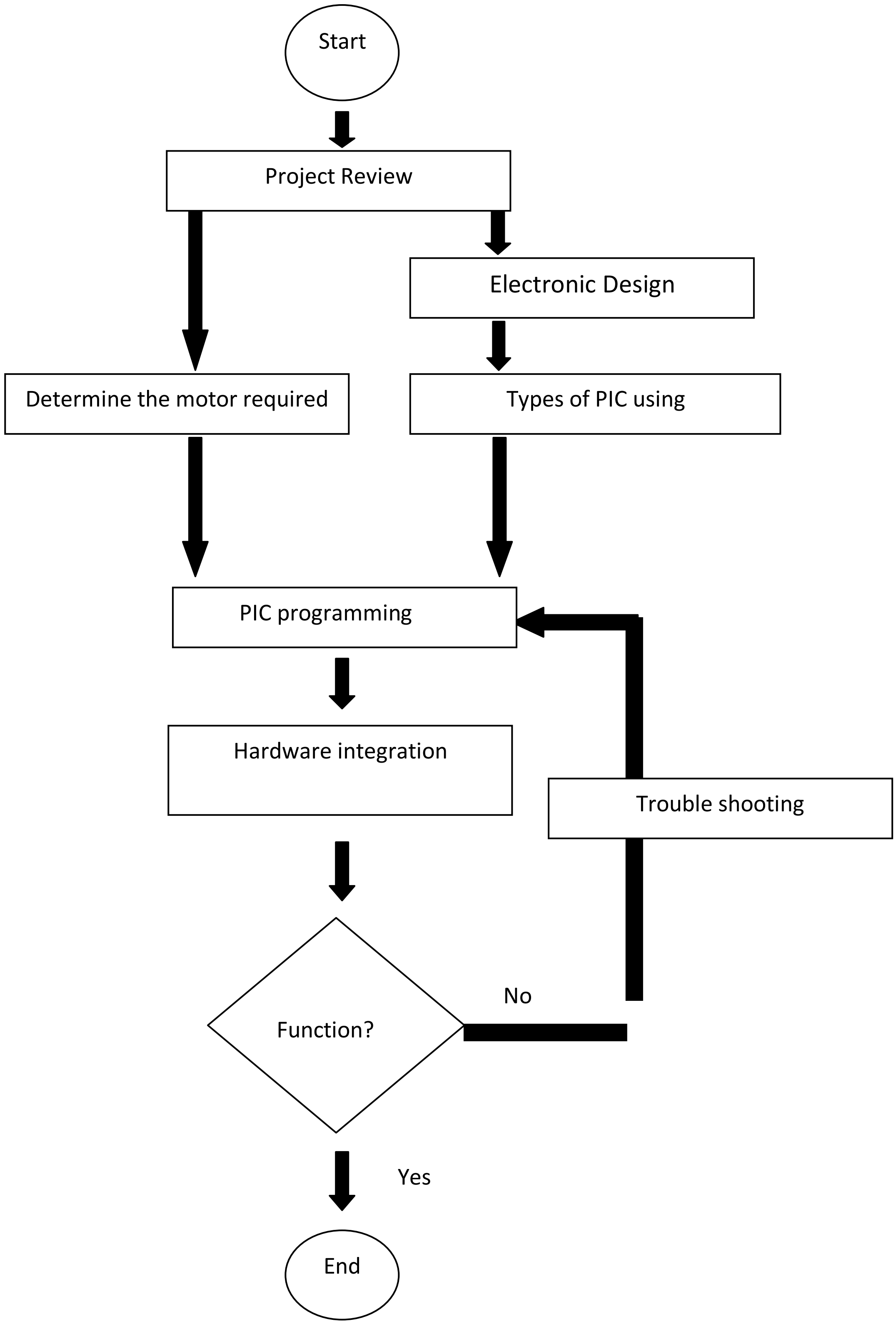

Figure 3.2: Flow chart for project

Figure 3.3 shows the picture of the project. The project is divides into two parts that are software and hardware implementation. Each part of the project will discuss in the following section.

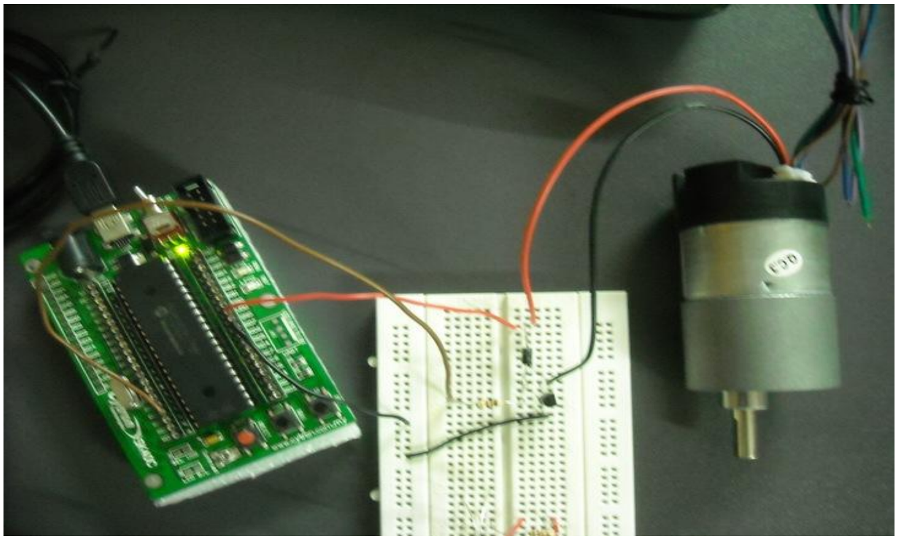

Figure 3.3: Picture of the project

3.1 Hardware Review

This section will discuss about components that had been used included DC motor, microcontroller PIC 16F877A, pulse-width-modulation (PWM) and DC Motor drive.

3.1.1 Circuit Overview

The motor control schematic circuit diagram is show in Figure 3.4. Port RC2(pin17) is connected to the 1kΩ resistor. The drive circuit consist of a resistor, transistor, and diode.

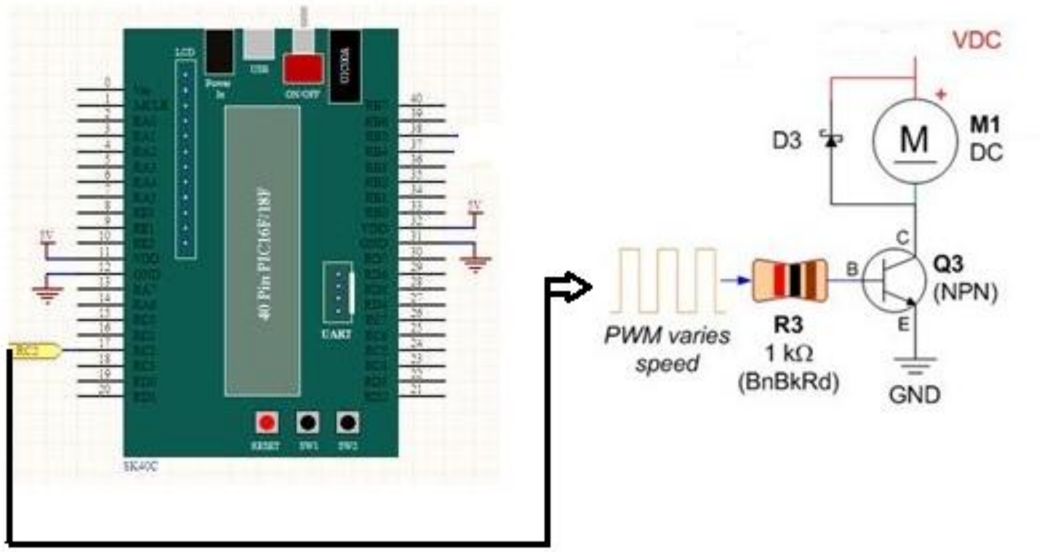

Figure 3.4: Circuit Diagram

The speed of the motor can be controlled by the duty cycle of the square wave, and:

- The transistor, Q3, should be more powerful than a 2N3904. A 2N2222 is suitable this DC motor.
- A diode, D3, has been added to reroute inductive motor spikes.

The PWM signal from the microcontroller feeds into the resistor of the transistor, and not directly to the motor. The resistor, transistor, and diode are all help to isolate the logic voltages from the motor voltages.

3.1.2. PIC Microcontroller Start-up Kit (SK40C)

This circuit board is designed to offer an easy to start board for PIC MCU user. All interface and program should be developed by user. This board comes with basic element for user to begin project development. It offer plug and use features 33 I/O pins which are nicely labeled to avoid miss-connection by users.. There is also provided connector for UIC00A (low cost USB ICSP PIC Programmer) for simple and fast method to load program.

SK40C comes with:

- 5V voltage regulator (1A max)
- 20MHz crystal oscillator
- Reset button
- 1 x programmable push button
- Connector for UIC00A
- On/Off switch for main power
- DC adaptor socket as power input
- And all the necessities to eliminate users difficulty in using PIC
- UART communication
- USB on board.

Figure 3.5: PIC Microcontroller Start-up Kit (SK40C)

3.1.3. PIC16F877A Microcontroller

The microcontroller acts like the brain of the DC motor speed control system. The microcontroller chip that has been selected for the purpose of controlling the speed of DC motor is PIC16F877A manufactured by Microchip. This chip is selected based on several reasons [8]:

i. Its size is small and equipped with sufficient output ports without having to use a decoder or multiplexer.
ii. Its portability and low current consumption.
iii. It has PWM inside the chip itself which allow us to vary the duty cycle of DC motor drive.
iv. It is a very simple but powerful microcontroller. Users would only need to learn 35 single word instructions in order to program the chip.
v. It can be programmed and reprogrammed easily (up to 10,000,000 cycles) using the universal programmer in robotics lab.

Refer to Figure 3.4 for the pin connection of PIC16F877A in DC Motor speed control system.

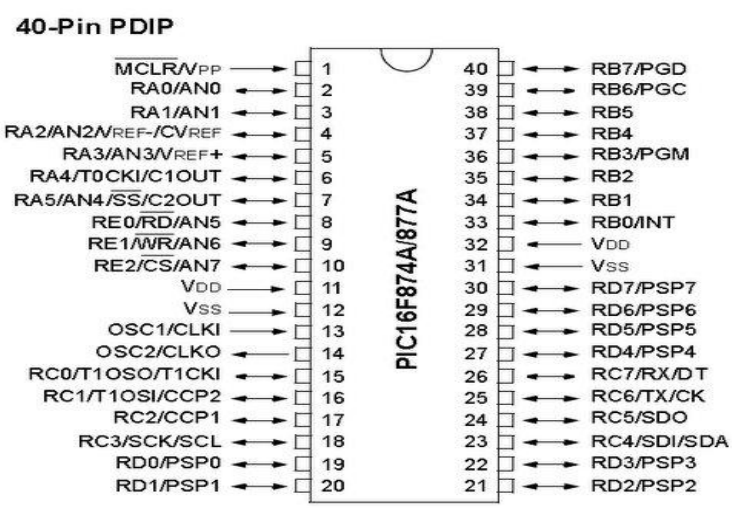

Figure 3.6: PIC16F877A Device

3.1.4. UIC00B USB ICSP PIC Programmer

UIC00B is a programmer designed to program popular Flash PIC Microcontroller which includes most of the PIC family. It can program 8bit, 16bit and 32bit PIC MCU. On board ICSP (In Circuit Serial Programming) connector offers flexible methods to load program.USB port is commonly available and widely used on Laptop and Desktop PC, thus is very convenient to use UIC00B.It compatible with Microchip's PICkit 2. It powered directly from USB port and no external power required for UIC00B to function. UIC00B also supports on-board programming which eliminates the need of plug-in and plug-out of PIC MCU ,this allows to modify the program without removing the PIC from the development board.

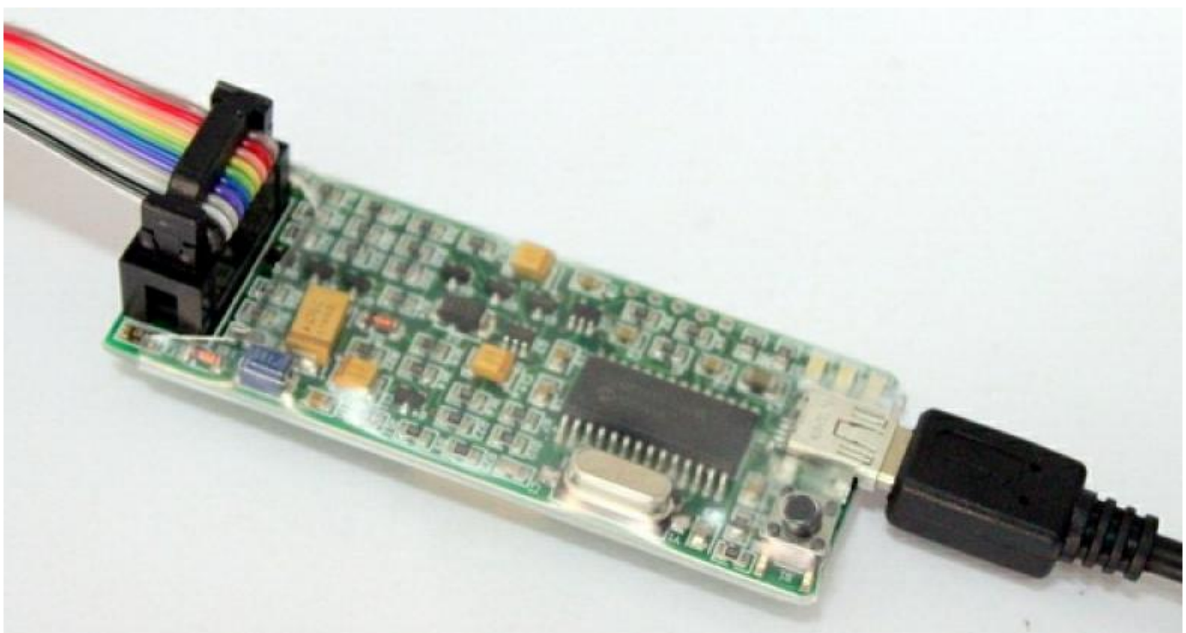

Figure 3.7: UIC00B USB ICSP PIC Programmer

3.1.5. DC Geared Motor

The SPG30-300K dc geared motor is been chosen to drive the robot. It have specification of max 12volt and having the speed of 12 RPM, 300:1 gear ratio, current at 410mA and also 1176mN.m torque. This dc geared motor is chosen because the speed necessary in low speed and also the higher torque value compare to other SP30 series geared motor.

Figure 3.8: SPG30-300K DC geared motor

3.1.6. Pulse Width Modulation (PWM)

The Pulse-Width-Modulation (PWM) in microcontroller is used to control duty cycle of DC motor drive.

PWM is an entirely different approach to controlling the speed of a DC motor. Power is supplied to the motor in square wave of constant voltage but varying pulse-width or duty cycle. Duty cycle refers to the percentage of one cycle during which duty cycle of a continuous train of pulses. Since the frequency is held constant while the on-off time is varied, the duty cycle of PWM is determined by the pulse width. Thus the power increases duty cycle in PWM.

The expression of duty cycle is determined by,

$$\%Dutycylcle = ton/T \text{ x } 100\%$$

Basically, the speed of a DC motor is a function of the input power and drive characteristics. While the area under an input pulse width train is measure of the average power available from such an input.

3. 2 SOFTWARE REVIEW

3.2.1 Background

Without software development, there is no use of establishing any project. In software development there is a need in programming the microcontroller. In this project the MPLab IDE compiler will be used to do the programming and it will convert to Hex file that can be read by PIC kit 2 programmers to program the programming into microchip.

3.2.2 Algorithm and Programming in MPLAB IDE

Microcontroller acts as brain of the whole DC motor speed control system. The actual speed is the end product as shown in Algorithm.

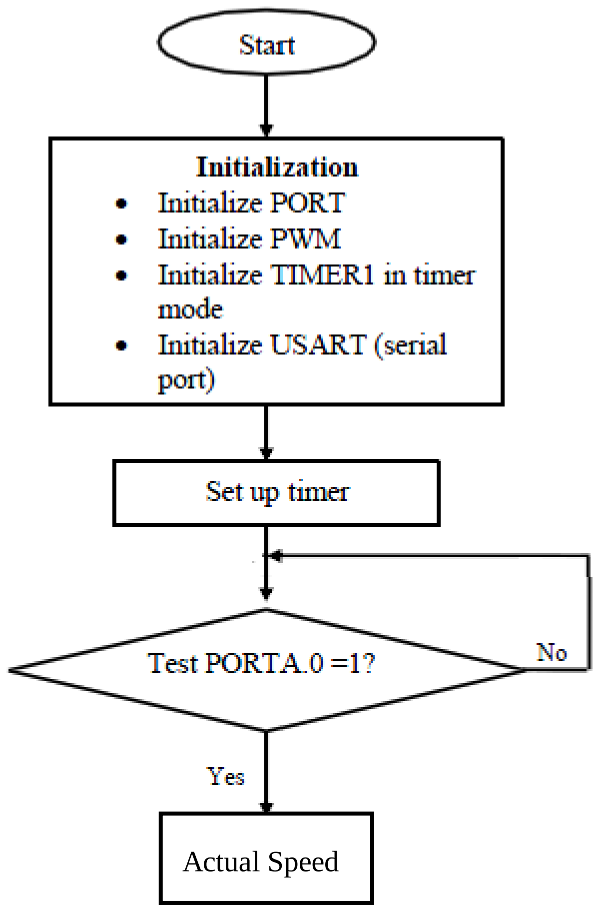

Figure 3.9: Motor Control Algorithms

3.2.2.1 Processing Explanation of Main Program

Regarding the setup for PWM operation, the following steps is taken when configuring the CCP module for PWM operation:

1. Set the PWM period by writing to the PR2 register.
2. Set the PWM duty cycle by writing to the CCPR1L register and CCP1CON<5:4> bits.
3. Make the CCP1 pin an output by clearing the TRISC<2>bit.
4. Set the TMR2 prescale value and enable Timer2 by writing to T2CON.
5. Configure the CCP1 module for PWM operation.

How to set the speed of a DC motor using PWM with PIC16F877A? First, initialize the CCP1 module to operate in PWM mode. Next use a formula to calculate PR2: PR2 = PWM period / (4xToscxTMR2 prescale). PWM period = 1/frequency. I set frequency = 4.88 kHz. So, the PR2 = 256.147, but the maximum could be reach is 255, so at the end, it will automatically go to 255 in decimal and FFh in hexadecimal. So the maximum speed that the motor can reach is 255 in CCPR1L. For example if CCPR1L = 0, that means the speed is 0% of the full speed, if CCPR1L = 255, that means the speed is 100% of the full speed.

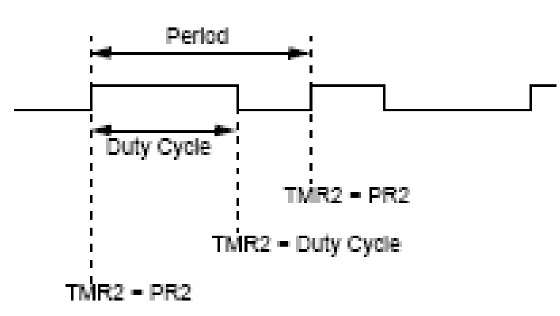

Figure 3.10: PWM output

3.2.3 PICkit 2 Programmer

To program the .he file into PIC16F887A, pickit 2 programmer is used. The UIC00B must be connecting to ICSP of sk40C board and also to pc using USB connecter. Wait for the device of PIC16F887A to be detected by pickit 2 programmer then go File , Import hex file, then the hex file of programming will be chosen and then click the write to program the .hex file into the microcontroller.

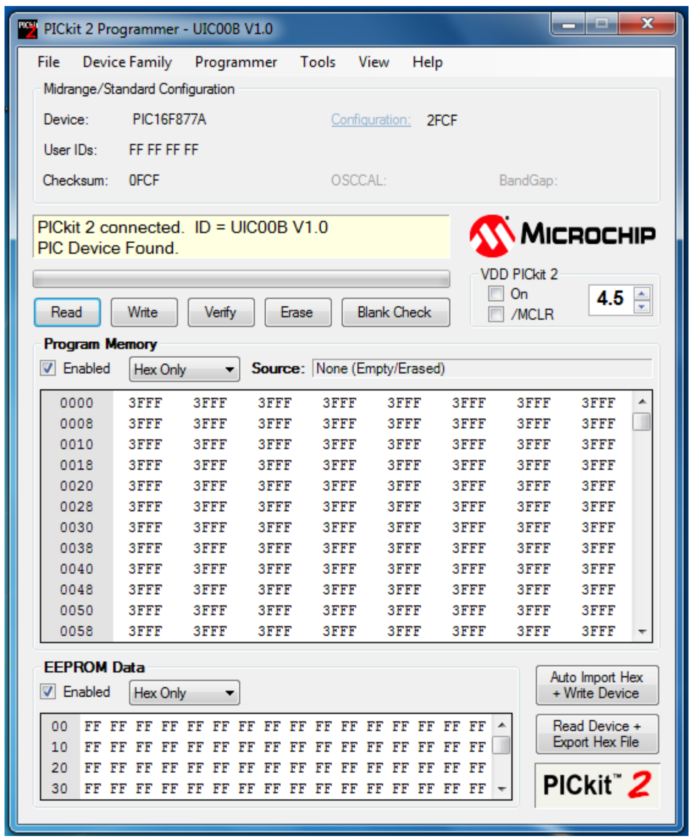

Figure 3.11: Detecting Device

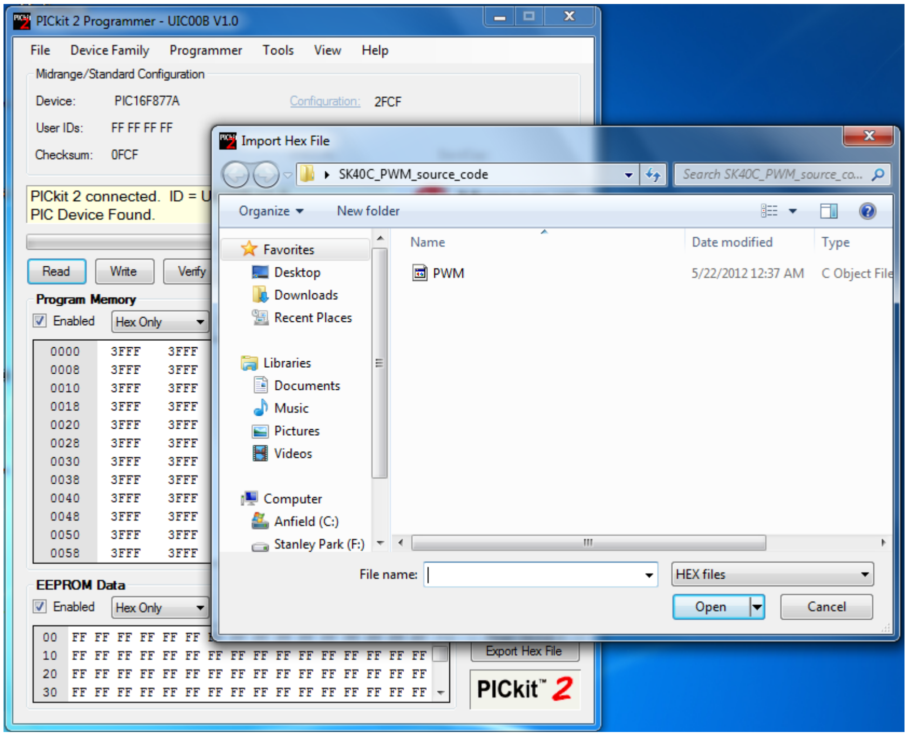

Figure 3.12: Selecting HEX file

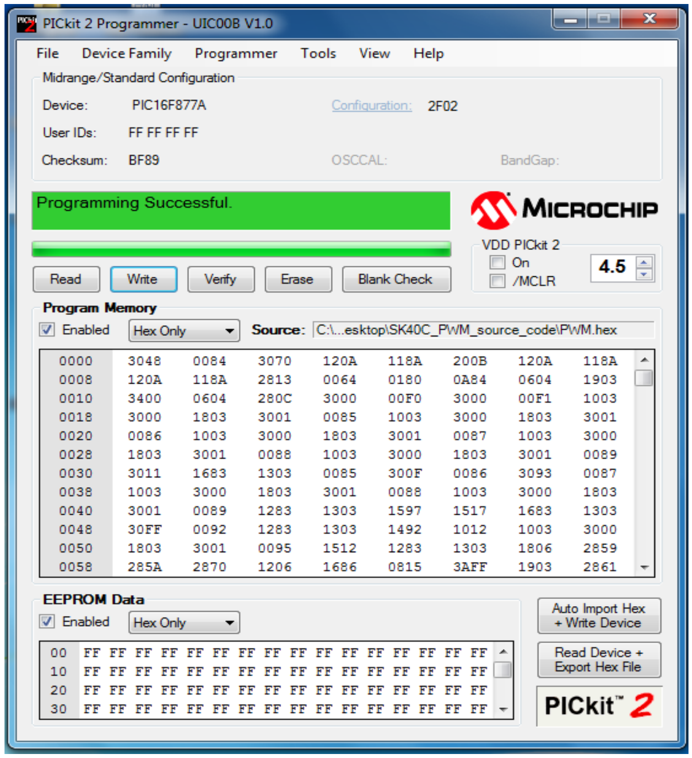

Figure 3.13: Write the programming into microchip

CHAPTER 4

RESULT & DISCUSSION

4.1 INTRODUCTION

First and foremost, an experiment is conducted to find out the relationship between PWM dutycycle, Average voltage supplied and motor speed. Then, data collection is done at each dutycycle percentage for DC motor speed control system to observe performance of the system.

4.2 Experiment: Determine Relationship of PWM Dutycycle/Voltage Supply and Motor Speed

An experiment is conducted to determine the relationship between voltage supply and speed. The procedures and the result will be discussed in following sections.

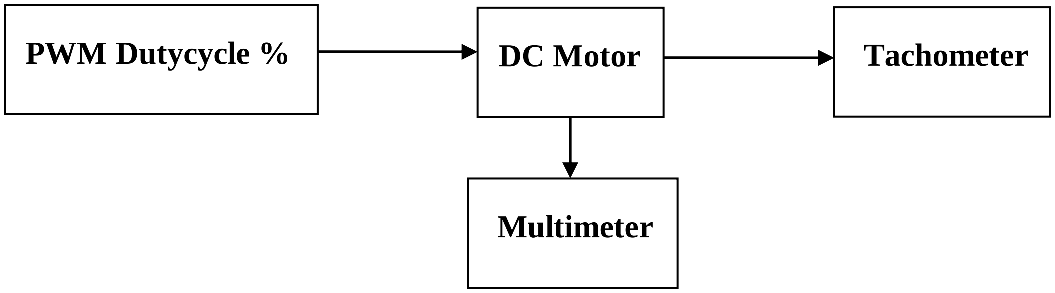

Figure 4.1: Experiment with Multimeter and Tachometer

4.2.1 Procedurs

1) The circuit was connected as Figure 4.1.
2) The PMW signal was supplied to motor.
3) Value of rpm at tachometer was recorded in Table 4.1.
4) Value of average voltage across motor was recorded in Table 4.1.
5) The PWM dutycycle percentage reduced from 100% to 0% and step 3 and 4 was repeated.
6) A graph of voltage-speed and dutycycle-speed was plotted.

4.2.2 Findings

a) At 100% dutycycle

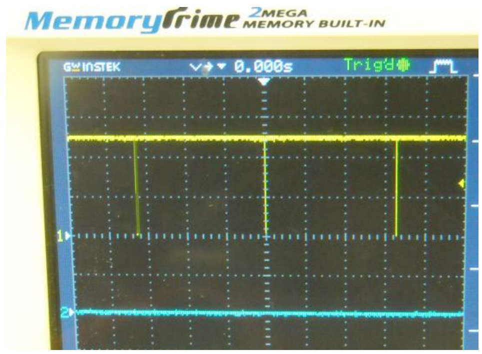

Figure 4.2: PWM at 100% dutycycle

Figure 4.3: Voltage reading at 100% dutycycle

Tachometer reading : 6.57rpm

b) At 90% dutycycle

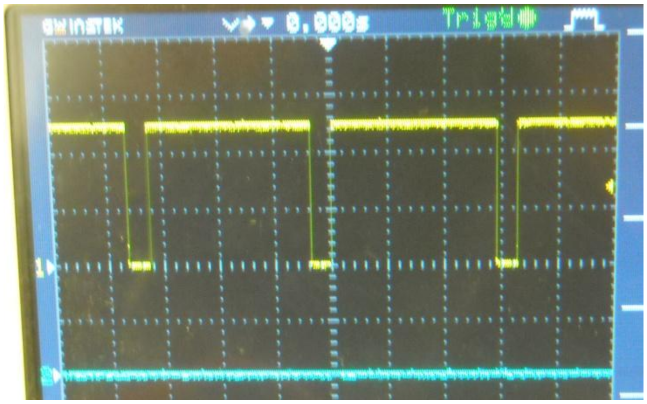

Figure 4.4: PWM at 90% dutycycle

Figure 4.5: Voltage reading at 90% dutycycle

Tachometer reading : 5.85rpm

c) At 75% dutycycle

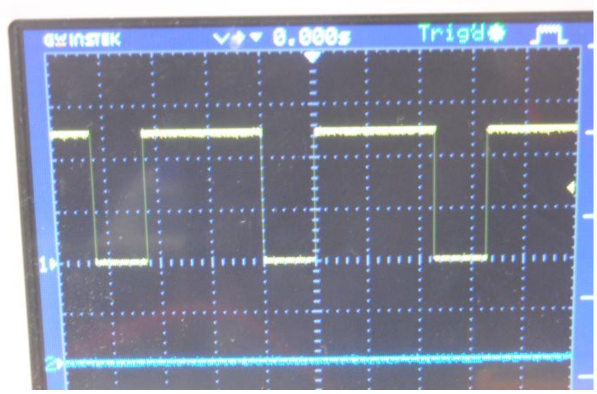

Figure 4.6: PWM at 75% dutycycle

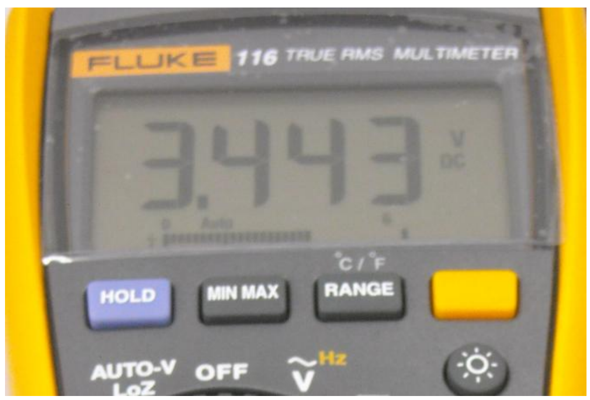

Figure 4.7 Voltage reading at 75% dutycycle

Tachometer reading : 4.59rpm

d) At 50% dutycycle

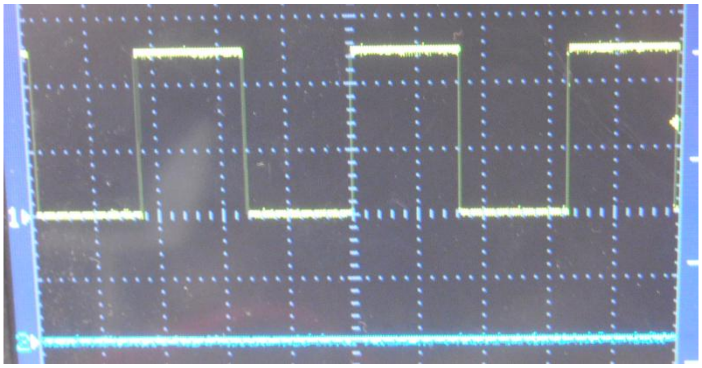

Figure 4.9: PWM at 50% dutycycle

Figure 4.10: Voltage reading at 50% dutycycle

Tachometer reading : 3.30rpm

e) At 25% dutycycle

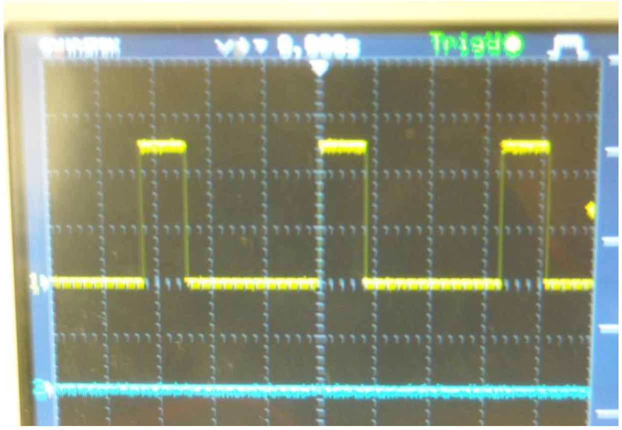

Figure 4.11: PWM at 25% dutycycle

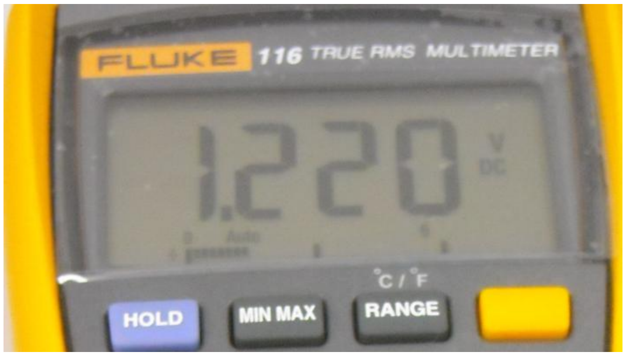

Figure 4.12: Voltage reading at 25% dutycycle

Tachometer reading : 1.63rpm

f) At 10% dutycycle

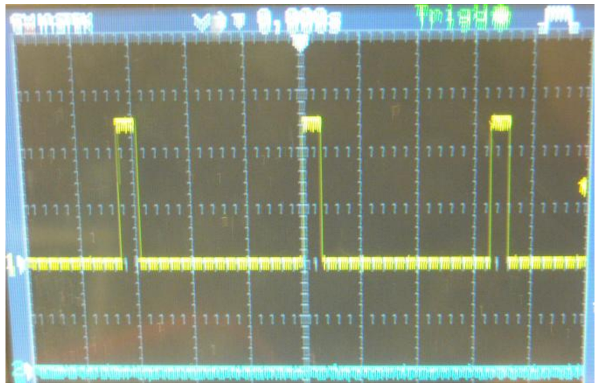

Figure 4.13: PWM at 10% dutycycle

Figure 4.14 Voltage reading at 10% dutycycle

Tachometer reading : 0.00rpm

g) At 0% dutycycle

Figure 4.15: PWM at 0% dutycycle

Figure 4.16: Voltage reading at 0% dutycycle

Tachometer reading : 0.00rpm

4.2.3 Experimental Result

From experiment, the data was recorded in Table 4.1.

Table 4.1: Relationship of Dutycycle, Voltage and Motor speed

Dutycycle (%)	Average Voltage (V)	Motor Speed (rpm)
100	4.93	6.57
90	4.39	5.85
75	3.44	4.59
50	2.48	3.3
25	1.22	1.63
10	0.49	0
0	0	0

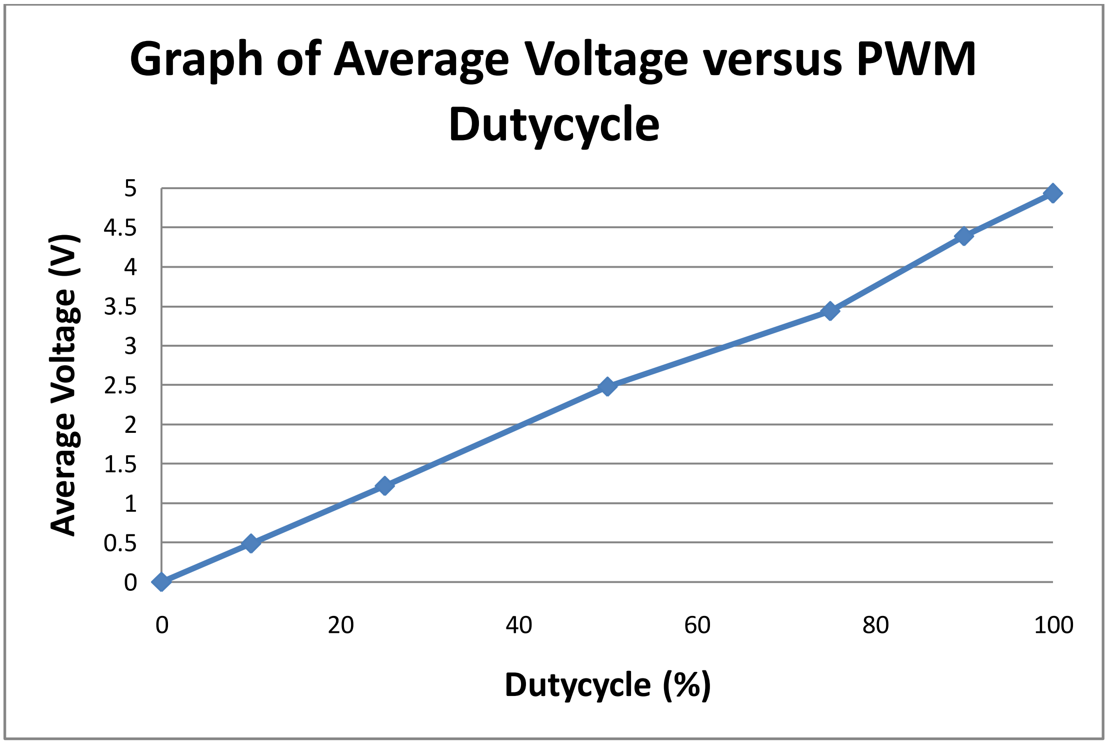

Figure 4.17 Graph of Average Voltage versus PWM Dutycycle

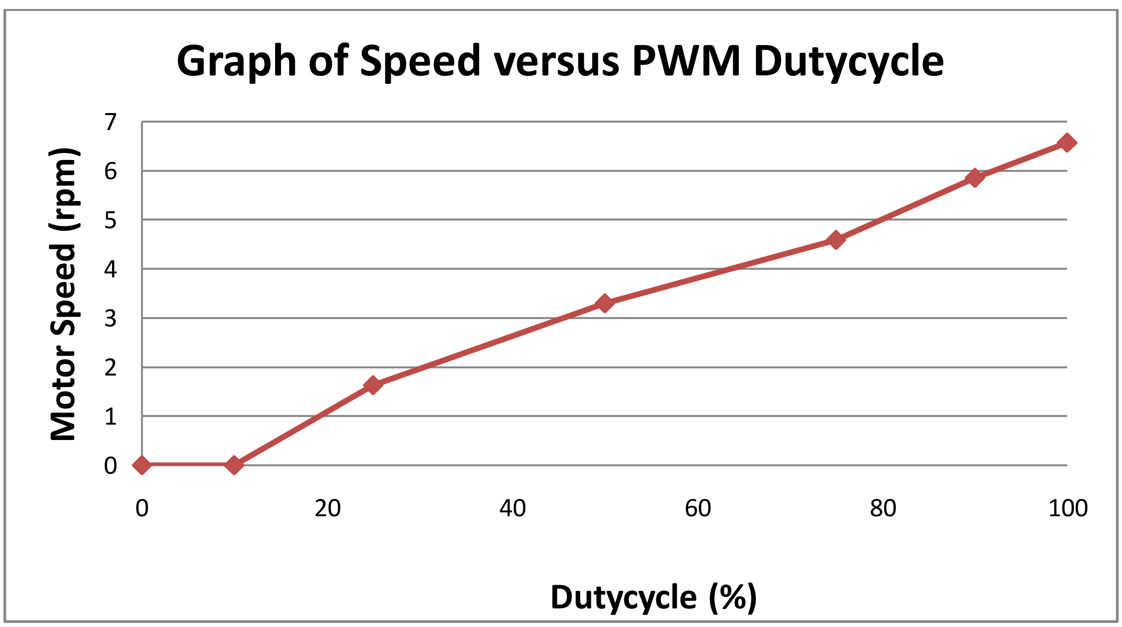

Figure 4.17 Graph of Speed versus PWM Dutycycle

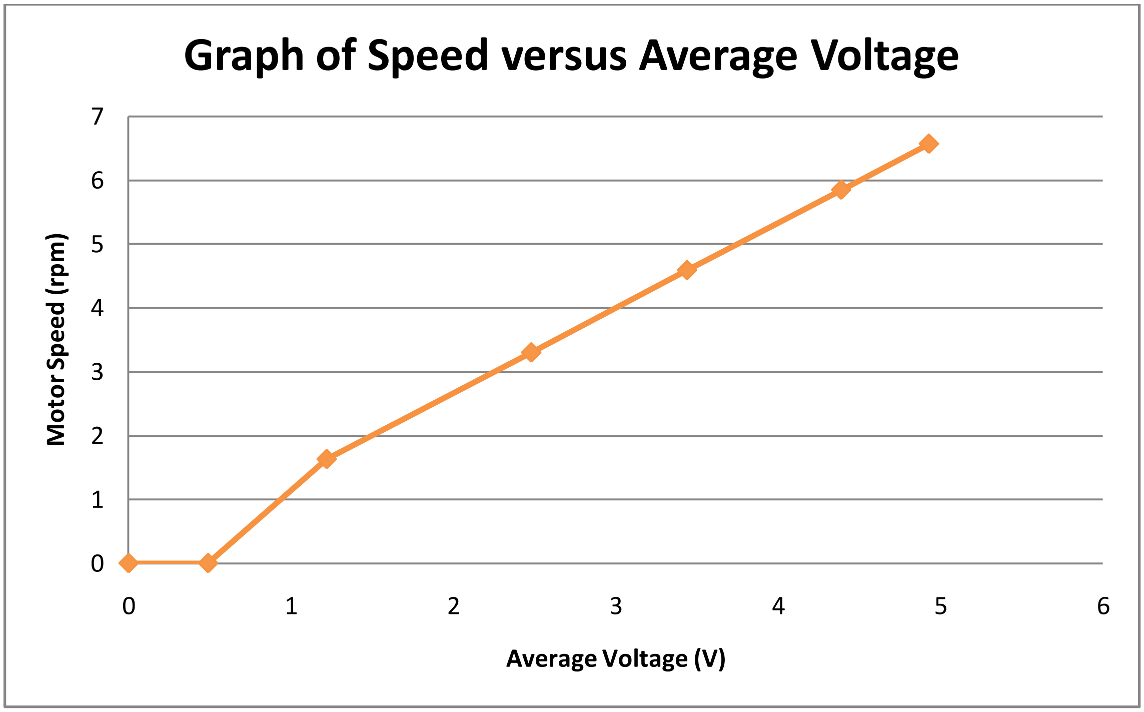

Figure 4.17 Graph of Speed versus Average Voltage

4.2.4 Analysis

As the Pulse Width Modulation (PWM) Dutycycle percentage increases, the average voltage across motor and motor speed increases respectively. This proves that PWM signal with bigger pulse carries higher average voltage and power. Thus this power is supplied to the DC motor for higher motor speed. Hence the decrease of PWM Dutycycle percentage will reduce the average voltage and power supplied to the Dc motor resulting in less motor speed.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

Recent developments in science and technology provide a wide range scope of applications of high performance DC motor drives in area such as rolling mills, chemical process, electric trains, robotic manipulators and the home electric appliances require speed controllers to perform tasks. DC motors have speed control capabilities, which means that speed, torque and even direction of rotation can be changed at anytime to meet new condition.

The goal of this project is to design a DC motor speed control system by using microcontroller PIC16F877A. The controller will maintain the speed at desired speed when there is a variation of power supply. By varying the PWM signal from microcontroller (*P* controller) the motor speed can be controlled to desired value easily.

It is found that the increase in PWM signal dutycycle percentage, also increase voltage supplied to the DC motor and motor speed.

In conclusion, the PWM signal can be varied microcontroller PIC 16F877A so that the motor speed can be maintained at desired value. The objective of the project is successfully fulfilled.

5.2 Problems

Although the controller can function as we expected, but the performance is slightly sluggish where it takes about 2 or 3 second to react properly when there is a disturbance especially at low speed. This is what we need to overcome in order to achieve quick control of motor speed smoothly.

DC motor with very small maximum speed is also hard to investigate its current speed when the dutycycle of PWM signal or the average power supply is too low. This is due inconsistency at very low voltage from the PWM signal.

5.3 Recommendations

The performance of the system is slightly sluggish. For future works, some recommendations have been listed based on the problems in order to improve the performance.

i. Mathematical modeling of motor response

Mathematical model can be obtained from the graph of motor speed response. Then, from the mathematical model, it can be simulated using software such as Matlab to get the improved motor speed response by using controller packages such as PID controller, Fuzzy Logic Controller and others. Besides, it will reduce the total hardware complexity and cost at the same time.

ii. Hardware Improvement

Use infra red (IR) as transmitter and receiver for optical encoder for more narrow light. So, these will allow us to increase the resolution of optical encoder by increasing the number of slots. Thus, it will reduce the steady state error (based on Equation 3.4). Besides, time for getting data and for controller to take action also can be reduced. So, the motor speed response will become better.

iii. Software Improvement

Use fuzzy logic microcontroller which combine the idea of fuzzy logic in microcontroller to obtain a DC motor speed control system with excellent regulation and high robustness.

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APPENDIX A

Program in Microcontroller PIC 16F877A for DC Motor Speed Control

```
/***************************************************************************
******

 File name : pwm
 Project : A direct current motor control led by microcontroller created PWM for driving
machine tool
 Programmer : THINESH A/L KUNASEGERAN
 Date : 27/3/2012
 Supervisor : PROFESSOR MADYA DR. AJISMAN APEN
***************************************************************************
******/


// Include all neccessary header files

#include <htc.h>   // include htc for HI-TECH header file for PIC

#include "system.h" // include hardware system define header file

//#include "adc.h"   // include adc initialization for correct digital and analog pin

//#include "lcd.h"   // include lcd library functions

#include "pwm.h"    // include pwm library functions

#include "pic.h"


/***************************************************************************
******

 Global Variables

***************************************************************************
******/


char string_buffer[40] = {0};
```

```
/*****************************************************************************
******
* MAIN FUNCTION                                                   *
******************************************************************************
******/
int main(void)
{
   unsigned int speed = 0;   // to store speed value
   // Initiate value for output pin
   PORTA = 0;
   PORTB = 0;
   PORTC = 0;
   PORTD = 0;
   PORTE = 0;
   // Initialize the I/Os.
   // There are 5 IO Ports on PIC16F877A (40 pin)
   // User is needed to initiate all I/O pin according to schematic
   // Most of un-use I/O is being configured as Input

   // Initialize the I/Os.
   TRISA = 0b00010001;
   TRISB = 0b00001111;
   TRISC = 0b10010011;
   TRISD = 0;
```

```
TRISE = 0;
CCP1M3 = 1;
CCP1M2 = 1;     // Configure CCP1 module to operate in PWM mode.
// Setting PWM frequency = 1.22khz.
PR2 = 0xff;
T2CKPS1 = 1;
T2CKPS0 = 0;  // Timer 2 prescale = 16.
CCPR1L = 0;     // Duty cycle = 0;
TMR2ON = 1;     // Turn on Timer 2, this will start the pulse generation at CCP1

while(1)
{

if (SW1 == 0)     // if SW1 is pressed
  {
    M1 = 0;
    M2 = 1;          // activate DC Brush motor in other direction
    if (CCPR1L <255)
    {
      CCPR1L += 1;      //increase speed by 1
      delay_ms(30);
    }
  //   CCPR1L = 255;      //~70% of full speed

  }
```

```
  else if (SW2 == 0)      // if SW2 is pressed
    {

      M1 = 0;
      M2 = 1;           // activate DC Brush motor in other direction
      if (CCPR1L > 0)
      {
        CCPR1L -= 1;      //decrease speed by 1
        delay_ms(30);
      }
    }
  }

  while(1) continue;    // Infinate loop at the end of program, prevent the PIC from reset
}

/*************************************************************************
******
* PRIVATE FUNCTION: delay_ms
*
* PARAMETERS:
* ~ ui_value   - The period for the delay in miliseconds.
*
* RETURN:
* ~ void
```

```
*
* DESCRIPTIONS:
* Delay in miliseconds.
*
********************************************************************************
******/
```