UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A STUDY AND DEVELOPMENT OF FOUR QUADRANT H-BRIDGE DC MOTOR CONTROLLER USING PIC18F4550

This report submitted in accordance with requirement of the
Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's
Degree in Electronics Engineering Technology (Industrial Electronics)(Hons.)

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology Department of Electronics & Computer Engineering Technology(Hons.). The member of the supervisory is as follow:

……

EN. A SHAMSUL RAHIMI BIN A SUBKI

ABSTRACT

Recently, motor applications not only use the maximum speed. It maybe uses only 5% of its speed. So, the speed of the motor must be control. For some applications, motor is using not only one direction but with alternate direction to control a machine. In industrial field, DC motor acting an important part in industrial. Besides, in modern era the manual controller is also not practical which can waste cost and time. According to this situation it is important to make a controller to control the speed of DC motor which user can monitor their system at certain place rather than going to the plant. Therefore, the aim of this project is to control direction either forward or backward of DC motor by using microcontroller and to study speed control of DC motor using PWM technique. It is operated by four quadrant H-Bridge DC motor controller using PIC18F4550.Four Quadrant Circuit is used in this circuit. It is create by using simulation software known as Proteus software. The simulation is also done for testing the four quadrant and also the control circuit. Four MOSFETS are used in the four quadrant circuit. Two of them are TIP 41C and TIP 42C. The four quadrant operation of the dc motor is best suited for industries where motors are used and as per requirement as they can rotate in clockwise, counter-clockwise and also apply brakes immediately in both the directions. The motor is controlled by using PWM which is pulse with modulation. It is observed that the voltage increases as the PWM increases. The maximum of the PWM is 255 whereas the maximum voltage is 5.101V. The LCD is also used in this project to show the maximum and minimum of the PWM. Overall, with this project, it can control not just the PWM, but the speed of the motor.

ABSTRAK

Pada masa sekarang, aplikasi motor tidak hanya digunakan pada kelajuan maksimum. Kemungkinan hanya menggunakan 5% sahaja kelajuannya. Maka, kelajuan boleh dikawal. Apa sesetengah aplikasi, motor tidak digunakan dalam satu arah untuk mengawal mesin. Dalam bidang industry, DC motor memainkan peranan yang amat penting. Pada era ini, kawalan manual juga tidak praktikal di mana dia amat membuang masa dan juga kos. Daripada situasi ini, kawalan had kelajuan amat berguna di mana pengguna boleh melihat keadaan yang berlaku. Dengan ini, objektif di dalam projek ini adalah untuk mengawal pergerakan motor dalam keadaan arah jam, arah lawan jam dan brek untuk berhenti pergerakan motor menggunakan kawalan mikro dalam masa yang sama kawalan kelajuan dapat dikaji dengan menggunakan teknik *Pulse width modulation (PWM)*. Ia menggunakan 4 kuadran jambatan H DC motor dengan menggunakan PIC18F4550. Litar jambatan H atau *H-Bridge* digunakan dalam projek ini. Simulasi juga digunakan dengan menggunakan Proteus dan barulah litar tersebut di lakukan secara praktikal. Empat MOSFET digunakan di dalam litar H-Bridge iaitu TIP41C dan TIP42C. Litar H-Bridge adalah pilihan yang bagus untuk pengoperasian putaran arah jam, lawan arah jam dan juga brek yang berlaku secara segera. Motor dikawal dengan menggunakan PWM di mana ia mengawal kelajuan. Pemerhatian terhadap kenaikan nilai voltan dikaji iaitu 5.101V pada voltan yang maksima pada nilai masukan 8V. Paparan LCD 16x2 juga digunakan untuk memaparkan maklumat. Pada keseluruhannya, projek ini bukan hanya untuk mengawal PWM sahaja malah ia mengawal kelajuan motor.

DEDICATIONS

I would like to dedicate this project to my beloved supervisor, En. A Shamsul Rahimi bin A Subki who give extra knowledge to assists me develop this project. I also want to thanks to my family members, lecturers and friends that give me extra spirit to continue develop this project.

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Alhamdulillah, praise be to Allah for His blessings and giving me the strength along the challenging journey of completing the project as well as this thesis writing, for without it, we would not have been able to come this far.

Primarily, we would like to take this opportunity to express my deepest gratitude towards my project supervisor, En. A Shamsul Rahimi bin A Subki who has Persistently and determinedly assisted me during the project. It would have been very arduous to complete this project without the passionate supports and guidance encouragement and advices given by him.

We outmost thanks also go to my family who has given me support throughout my academic years. Without them, we might not be able to become who we are today. we grateful to have love affection and care from all of my family members as well. My fellow friends should also be recognized for their continuous support and encouragement. we sincere appreciation also extends to my entire course mate and others who have provided assistance at various occasions. Their views and tips are useful definitely.

Last but not least, thanks to individuals that has contributed either directly or indirectly to make this thesis project. Without all these people encouragement, support, and advices this thesis project might not be successfully carried out. Of course, as usual, all errors and oversights are entirely my own. Thank you once again

TABLE OF CONTENT

LIST OF FIGURE

LIST OF TABLE

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

The main goal for this project is to build a motor controller that can control a DC motor with a digital input. For the purpose of this project, a microcontroller is use to turn the motor in four quadrant which are forward, reverse, forward breaking and reverse breaking. There should be one digital input for forward and one digital input for backward. Additionally the board should have two terminal blocks, one for the motor's power and one for connecting the H-bridge to the motor.

As an application of H-Bridge motor controller (DC motors) can be used as wheel drive machines and by using a simple microcontrollerPIC18F4550 the rotation of motors or motion of the robots can be controlled easily. The motion of the motor is based on the concept of differential mechanism. The prerequisites are DIY PCB (Etching), DC Motor Control and H-Bridge circuit

1.2 PROBLEM STATEMENT

In real world, motor applications not only use the maximum speed. It maybe uses only 5% of its speed. So, the speed of the motor must be control. For some applications, motor is using not only one direction but with alternate direction to control a machine. In industrial field, DC motor acting an important part in industrial. There are some types of applications need the load on the DC motor varies a speed range such as high precision digital tools, rolling mill, and double-hulled tanker.

Besides, in modern era the manual controller is also not practical which can waste cost and time. According to this situation it is important to make a controller to control the speed of DC motor which user can monitor their system at certain place rather than going to the plant. Furthermore this system is more precise and reliable which can reduced the man power. The hardware may be need a higher cost with maintenance but the low cost electronic devices can be design for this system but some machine or robot cannot get in touch according to safety and the location of those things. The system will create the program source code and conduct by designing circuit which contains H-bridge circuit, control circuit and DC motor

1.3 OBJECTIVES

The project objective contains in two part which are primary objective and secondary objective. Primary objectives are about the direction of the motor rotation and PWM technique. While secondary objective are about the source code and the four quadrant system of DC motor.

1. To control direction either forward or backward of DC motor by using microcontroller.
2. To study speed control of DC motor using PWM technique.
3. To develop a source code using assembly language of the microcontroller

1.4 PROJECT SCOPE

Project scope have two categories must be archive. It is start from software implementation until hardware installation. The project is implemented based on the scope. Among them :

1) Design a circuit for controlling motor of DC motor.
    i. The H-Bridge.
    ii. Motor Control Hardware with a PIC.
    iii. Integration to Control a DC Motor.
2) Develop programming for the microcontroller.

1.5 THESIS OUTLINE

Chapter 1 :

This chapter introduces brief idea of the project. It focused on the overview of the project, detailing the objectives, the problem statement, scope and outcome of the project.

Chapter 2 :

Projects background is discussed in this chapter. The method concept, theory, and some characteristic of component of hardware that are used in this project is discussed in this chapter. This chapter also defines terms used in this project and discussed the concept of the research and how it is related with the theory.

Chapter 3 :

Describes the methodology used in this project. The schedule or steps that need to be completed and the detailed reports of studies that were done to achieve the aim of the project are presented.

Chapter 4 :

This chapter presents the result and discussion. All the simulations, data collection and analysis obtained will be discussed in detail. The results will be compared with the objectives outlined in order to arrive to some hypothesis and conclusion.

Chapter 5:

The conclusion and future work that can be undertaken. Some recommendations and suggestion on how to improve the performance of the system based on the desired results will be given.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is used as one of the method for the purpose of learning and to gain more knowledge in terms of project, designing the circuit and also to understand in details on the problem of designing the DC motor circuit.

2.2 TYPES OF DC MOTOR

2.2.1 DC motor

DC motors are one of the simplest types of motors to be controlling. A few DC motors that I will use to test the circuit, anything that doesn't require more than 10A to move will do.

The first consideration is the motor's nominal voltage. DC motor as in figure 2.1 is controllers tend to offer a voltage range. For example, if the motor operates at 3V nominal, it should not select a motor controller that can only control a motor between 6V and 9V.

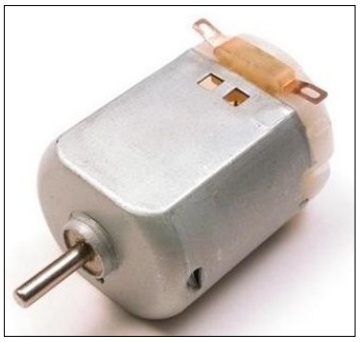

Figure 2.1 DC Motor

Once found a range of controllers that can power the motor with the appropriate voltage, the next consideration is the continuous current the controller will need to supply. Find a motor controller that will provide current equal to or above the motor's continuous current consumption under load. Should be choose a 5A motor controller for a 3A motor, the motors will only take as much current as they require. On the other hand, a 5A motors is likely to burn a 3A motor controller. Many motor manufacturers provide a DC motor's stall current, which does not give a clear idea of the motor controller will need. If cannot find the motor's continuous operating current, a simple rule of thumb is to estimate the motor's continuous current at about 20% to 25% of the stall current. All DC motor controllers provide a maximum current rating – be certain this rating is about double that of the motor's continuous operating current. Note that when a motor needs to produce more torque (for example going up an incline), it requires more current. Choosing a motor controller with built-in over current and thermal protection is a very good choice.

The Control method is another important consideration. Control methods include analogue voltage, I^2C, PWM, R/C, UART (a.k.a. serial). If using a microcontroller, check to see which pin types have available and which motors are viable to choose. If the microcontroller has serial communication pins, choose a serial motor controller; for PWM, will likely need one PWM channel per motor.

2.2.2 Servo Motor Control

Since standard hobbyist servo motors are meant to use specific voltages (for peak efficiency), most operate at 4.8V to 6V, and their current consumption is similar, the steps for the selection are somewhat simplified. However, it may find a servo motor as shown in Figure 2.2 that operates at 12V; it is important to do additional research about a servo motor controller if the servo motor is not considered "standard".

Figure 2.2 Servo Motor

Also, most hobby servo motors use the standard R/C servo input (three wires which are ground, voltage and signal). Choose the control method. Some servo motor controllers allow to control the servo's position manually using a dial/switch/buttons, while others communicate using UART (serial) commands or other means. Determine the number of servos to be controlled . Servo controllers can control many servos (usually 8, 16, 32, 64 and up). As with DC motor controllers, the control method is an important consideration.

2.2.3 Stepper Motor Control

A stepper motor as shown in Figure 2.3 is controller type accordingly, though a growing number are able to control both types. The number of leads is usually a dead give-away of the motor type: if the motor has 4 leads, then it is bipolar; should it have 6 or more leads, then it is unipolar.

Figure 2.3 Stepper Motor

Choose the motor controller voltage range to match that motor's nominal voltage . Find out how much current per coil the motor requires, and find out how much current (per coil) the stepper motor controller can provide . Using Ohms Law (V=IR), then calculate the current (I). As with DC motor controllers, the control method is an important consideration.

2.3 PREVIOUS RESEARCH

Before beginning the process of designing a h-bridge circuit, some of the existing circuit should be learn.

2.3.1 Working and Analysis of the H– bridge Motor Driver Circuit Designed for Wheeled Mobile Robots from Vibhor Gupta, University Institute of Engineering and Technology, Panjab University, Chandigarh (2000).

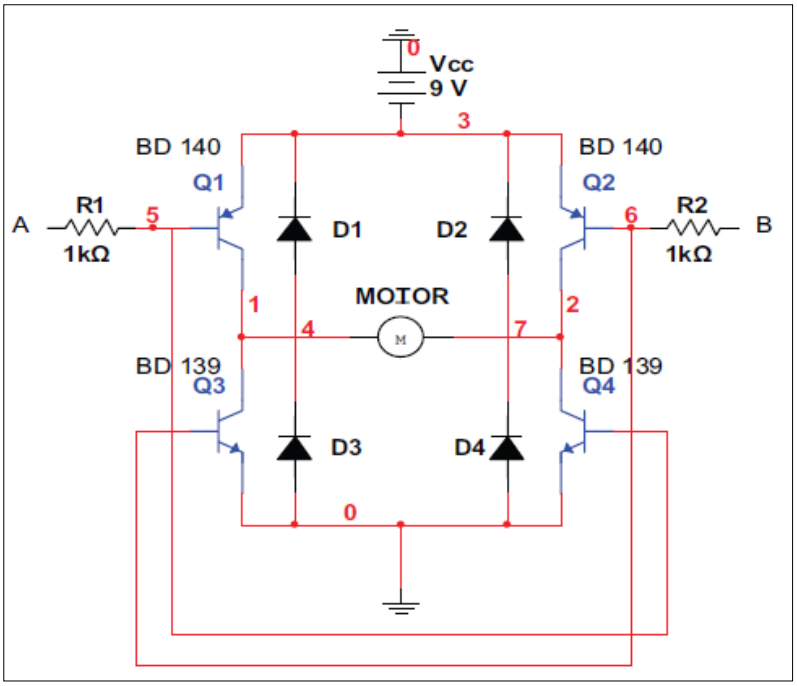

Figure 2.4 H- Bridge Motor Driver Circuit

Simulation and construction of circuits, National instruments Multisim *"www.ni.com/help"*[8]

The DC geared motor will work in two directions (Clockwise or anticlockwise) depending upon the direction of flow of current from it. The Inputs A and B will be fed from the microcontroller PIC 16F 877A [2] refer Figure 2.4. Transistors Q1 and Q4 and transistors Q2 and Q3 are given the same input. When A is HIGH, while B is LOW, transistors Q2 and Q3 triggers making the movement of the motors in one direction. Similarly when A is LOW, while B is HIGH, transistors Q1 and Q4 triggers making the direction of the motor opposite.

The transistors used are BD 139(NPN) and BD 140(PNP) as shown in Table 2.2. These are power transistors which are able to withstand the high starting current of the motors due to starting torque from the gears, unlike simple BJT's.

TABLE 2.1 Characteristics of BD 139 and BD 140 [3]

Symbol	Parameter	Max.	Unit
VCBO	Collector-base voltage	100	V
VCBO	Collector-emitter voltage	80	V
IC	Collector current (DC)	1.5	A
Ptot	Total power dissipation	8	W
hFE	DC current gain IC = 150mA ; VCE = 2V	250	V

A drive system for the wheeled mobile robots should be efficient enough to provide good movement. The circuits explained will help to make a drive system efficient and is able to work at heavy load conditions with proper switching.