DC MOTOR SPEED CONTROLLER USING PIC16F876A

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"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronics and Drives)"

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Date : 07 / 05 / 2008

"I declared that this work as the product of my own effort with the exception of accepts cited from others work of which the sources were duly noted in the references."

Signature : Akmal Hakim
....

Name : AKMAL HAKIM BIN MUSAH

Date : 07 / 05 / 2008

Dedicated, in thankful appreciation for support, encouragement and understandings to my beloved mother, father, brothers and sisters to give me support for my work to get through this.

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Alhamdulillah, praise be to Allah, the Cherisher and Sustainer of world, most Gracious, most Merciful Lord.

Praise be to Allah for enabling me to completed this analysis and research for 'DC Motor Speed Controller using PIC16F876A' project and report for my "Projek Sarjana Muda".

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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 the number of applications using them will continue grow for the foreseeable future. This project is mainly concerned on DC motor speed control system by using microcontroller PIC 16F876A. Pulse Width Modulation (PWM) technique is used where its signal is generated in microcontroller. Microcontroller acts as proportional (*P*) controller in this project. The PWM signal will send to motor driver to vary the voltage supply to motor to maintain at constant speed. A program Proteus is use to simulate the DC motor speed circuit and setup the PIC 16F876A using MicroC to make a simulation successful. Through the project, it can be concluded that microcontroller PIC 16F876A can control motor speed at desired speed with variable the speed with given pulse in order to increase or decrease.

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 pada masa depan. Projek ini tertumpu kepada rekaaan satu sistem kawalan kelajuan motor arus terus dengan menggunakan mikropengawal PIC 16F876A. Teknik "Pulse Width Modulation" (PWM) digunakan di mana isyarat ini dibekal oleh mikro pengawal. Mikropengawal berperanan sebagai pengawal gandaan, P 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 ditetapkan. Satu program ditulis dalam MicroC dan disimulasi menggunakan program Proteus 7 Professional untuk memprogram PIC16F876A. Melalui projek ini, boleh disimpulkan bahawa mikropengawal PIC 16F876A dapat mengawal kelajuan motor pada kelajuan yang dikawal dengan mengawal isyarat masukan samada untuk menambah atau mengurangkan kelajuan.

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LIST OF ABBREVIATIONS

DC	**Direct Current**
CAN	**Control Area Network**
CCW	**Counter Clock Wise**
CW	**Clock Wise**
GND	**Ground**
GUI	**Graphical Using Interface**
IC	**Integrated Chip**
IR	**Infrared**
MOSFET	**Metal Oxide Semiconductor Field Effect Transistor**
PCB	**Printed Circuit Board**
PIC	**Peripheral Interface Controller**
PID	**Proportional Integral Derivative**
PROM	**Programmable Read Only Memory**
PWM	**Pulse Width Modulation**
RAM	**Random Access Memory**
ROM	**Read Only Memory**
RPM	**Revolution per Minute**
SCR	**Silicon Controlled Rectifier**
USB	**Universal Serial Bus**

LIST OF APPENDICES

CHAPTER 1.0

INTRODUCTION

1.1 Background

Direct current (DC) motors have variable characteristics and are used extensively in variable-speed drives. DC motor can provide a high starting torque and it is also possible to obtain speed control over wide range. Why do we need a speed motor controller? For example, if used a DC motor in a robot, if it just apply a constant power to each motor on a robot, then the poor robot will never be able to maintain a steady speed. It will go slower over carpet, faster over smooth flooring, slower up hill, faster down hill, etc. So, it is important to make a controller to control the speed of DC motor in desired speed.

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.

1.2 Objective of Project

The main core of this project is to design a speed control system of DC Motor by using microcontroller. This system will be able to control the DC motor speed at desired speed regardless the changes of load.

Therefore, the main objective of this project can be defined as:

- To design a DC motor controller where can control speed for output motor.
- To determine how the PIC can be use to produce the output for motor.
- To analysis on the speed controller for automation system.

1.3 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 hardware, software and graphical using interface (GUI). The hardware sections in this project are modeling the DC speed motor using MATLAB, design the PIC and DC speed motor circuit. In software section, MicroC will be use to program microcontroller PIC 16F876A and simulate the system with PROTEUS software to get the initial result. The graphical using interface (GUI) will be use to interfacing, send data and display the result. This system will interface to a personal computer through USB Port. The result will be present in output response.

1.4 Problem Statement

Mostly of the existing control system nowadays is using the PID as a microcontroller. However, in this project needed to build a control system that use PIC as a microcontroller. DC speed motor controller will be use as a plant and need to function as an automation system for control the speed of the motor.

CHAPTER 2.0

LITERATURE REVIEW

2.1 Speed Control by Using PWM and Full H Bridge Motor Drive

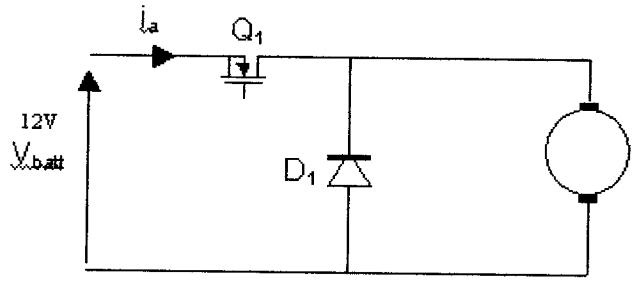

Figure 2.1: Simple Motor Circuit [10]

For a simple circuit that connects a battery as power supply through a switch MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) as shown in Figure 2.1 [5]. When the switch is closed, the motor sees 12 Volts, and when it is open it sees 0 Volts. If the switch is open for the same amount of time as it is closed, the motor will see an average of 6 Volts, and will run more slowly accordingly.

This on-off switching is performed by power MOSFETs. A MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) is a device that can turn very large currents on and off under the control of a low signal level voltage.

The average of voltage that supply to DC motor is given by,

$$V_{ave} = \frac{t_{on}}{T} \times V_{in} \qquad (2.1)$$

where V_{ave} = average voltage supply to DC motor

t_{on} = time ON of switches

T = period of PWM

$\frac{t_{on}}{T} = DC$, duty cycle

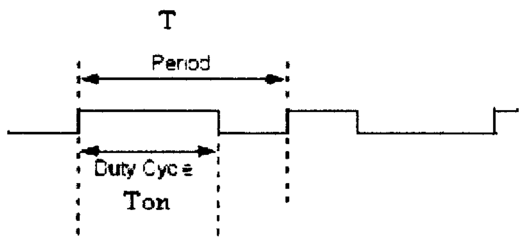

Figure 2.2: PWM Signal

As the amount of time that the voltage is on increases compared with the amount of time that it is off, the average speed of the motor increases and vice versa.

The time that it takes a motor to speed up and slow down under switching conditions is depends on the inertia of the rotor (basically how heavy it is), and how much friction and load torque there is. Figure 2.3 shows the speed of a motor that is being turned on and off fairly slowly:

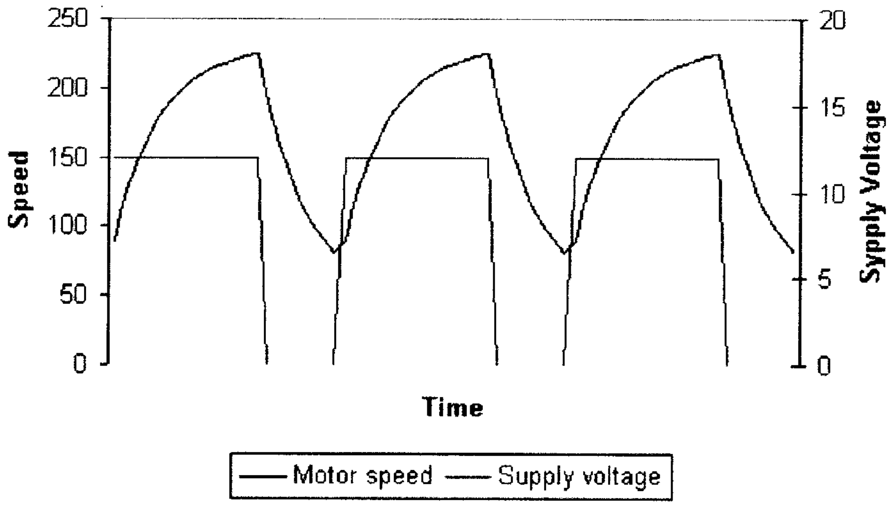

Figure 2.3: Relation of Supply Voltage with Motor Speed

From Figure 2.3, it shown the average speed is around 150 rpm, although it varies quite a bit. If the supply voltage is switched fast enough, it won't have time to change speed much, and the speed will be quite steady. This is the principle of switch mode speed control. Thus the speed is set by PWM – Pulse Width Modulation.

A full bridge circuit is shown in the diagram below. Each side of the motor can be connected either to battery positive, or to battery negative. Only one MOSFET on each side of the motor must be turned on at any one time otherwise they will short out the battery and burn out.

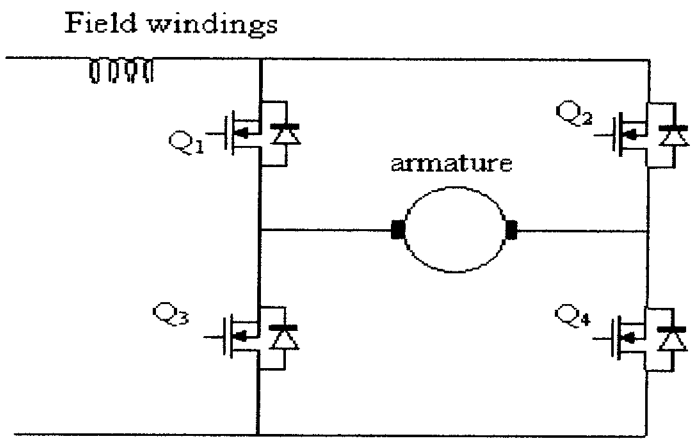

Figure 2.4: Full H Bridge Motor Drive [10]

To make the motor go forwards, Q4 is turned on, and Q1 has the PWM signal applied to it. Meanwhile, to make the motor go backwards, Q3 is turned on, and Q2 has the PWM signal applied to it.

2.2 A PID Controller for Real-Time DC Motor Speed Control using the C505C Microcontroller

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2.2.1 Abstract

This paper presents a real-time DC Motor speed controller design using a microcontroller-based network system. The design architecture was developed using two Phytec evaluation boards each having an Infineon 8-bit C505C-L microcontroller. The system detects the real-time speed of the motor using the sensor device and then transfers data to the first Phytec board's microcontroller using serial communication. This data is processed and transferred to the second Phytec board's microcontroller using a Controller Area Network (CAN) communication scheme.

The second microcontroller uses the received data to calculate the real-time control value to monitor and keep the motor speed constant based on a command signal. Data is then transferred back to the first Phytec board's microcontroller using CAN and is utilized to change the motor voltage such that its speed is constant. The importance of the proposed design architecture is its ability in controlling precisely the motor speed and/or direction especially when used in modern automobiles where the CAN protocol is quite popular. Moreover, the proposed real-time controller approach is based on the closed loop feedback error principle unlike the existing open loop designs. The paper details the system design and the experimental results that were obtained.

2.2.2 Digital Controller Design and Simulation

Figure 2.5 shows the block diagram of the proposed digital PID controller, where R(s) is the reference input, y(s) is the system output, C(s) is the controller transfer function, and H(s) is the feedback loop (sensor) transfer function.

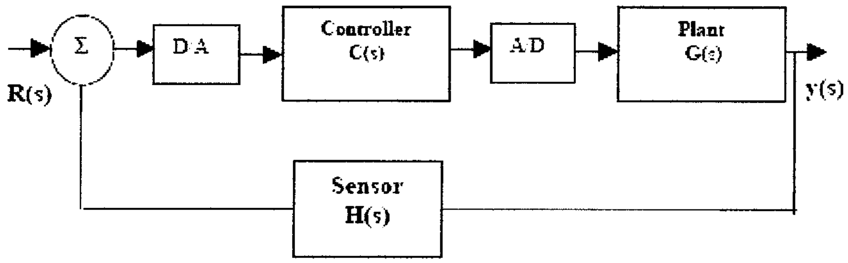

Figure 2.5: Discrete PID Controller Structure [5]

The developed DC motor model and the closed loop system are then used to generate the coefficients of the digital PID controller using MATLAB. Figure 2.6 shows the settling time for the model for a motor input set point of 15 revolutions per second (rps). Considering this settling time for the practical DC motor model, the coefficients of the discrete PID constants are formulated for the closed loop system. Further, using these coefficients from, the following coefficient matrices are also obtained for the DC motor equation.

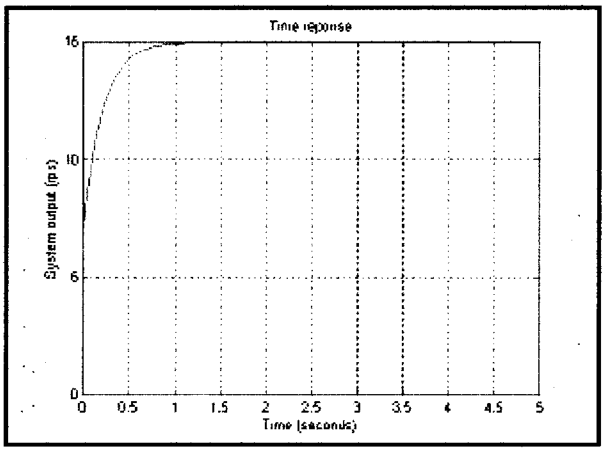

Figure 2.6: Step Response of the DC Motor Model [5]

2.2.3 Simulation and Test Result

To test the system, the reference speed was set to about 4.5V (about 50% D). The motor speed was then displayed on a desktop computer using the HyperTerminal software, and transferred to microcontroller M2. The controller software embedded within M2 calculates the necessary duty cycle required for maintaining the motor speed at the required constant value. Figure 2.7 shows the actual output voltage waveform and the input set point. The codes were generated using the DAvE and µVision2 software programs. The software was written in 'C' language.

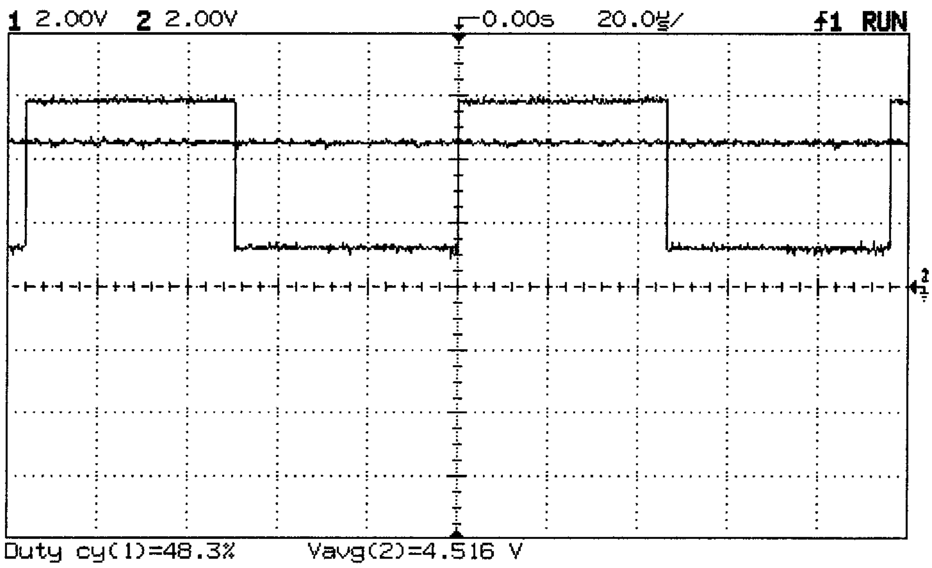

Figure 2.7: Output and Input Voltage Changes [5]

The proposed design uses a Dearborn Protocol Adapter II (DPA-II) to monitor the CAN system bus and uses a practical DC motor model. Figures 2.8 and 2.9 show the simulation results for a change in the speed value and the motor speed corresponding to the above change. As can be seen from Figure 2.8, a speed change of around 1.5 – 1.7 rps is continuously fed using a potentiometer. The remote controller has been applied in the forward loop based on the DC motor model and the updated value of the controller is used each time as the motor input using the CAN bus. The speed variation at each instant along with the controller action is observed. It was noted that the motor output is within the range of set point speed, which is 14.5 - 15.5 rps. Thus, the controller action is effective as the actual speed without the controller should drop to 13.3 – 13.5 rps during the snap-shot time span of 1 second. Figure 2.9 also shows the controller response during this period.

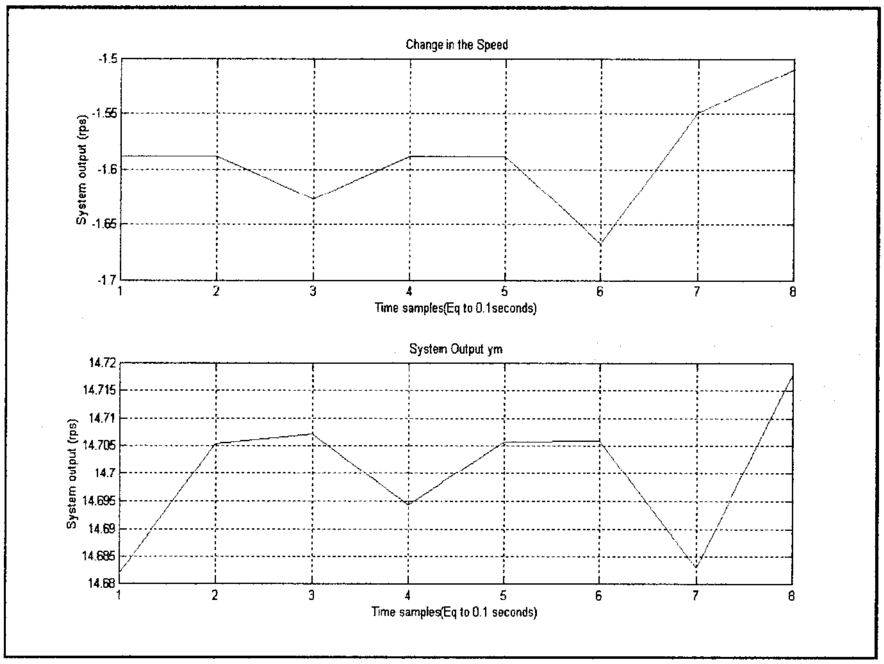

Figure 2.8: Motor Speed Changes [5]