Four Quadrant Speed Control of DC Motor with the Help of AT89S52 Microcontroller

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Abstract

Speed control of a machine is the most vital and important part in any industrial organization. This paper is designed to develop a four quadrant speed control system for a DC motor using microcontroller. The motor is operated in four quadrants i.e. clockwise, counter clock-wise, forward brake and reverse brake. It also has a feature of speed control. The four quadrant operation of the dc motor is best suited for industries where motors are used and as per requirement they can rotate in clockwise, counter-clockwise and also apply brakes immediately in both the directions. In case of a specific operation in industrial environment, the motor needs to be stopped immediately. In such scenario, this proposed system is very apt as forward brake and reverse brake are its integral features. Instantaneous brake in both the directions happens as a result of applying a reverse voltage across the running motor for a brief period and the speed control of the motor can be achieved with the PWM pulses generated by the microcontroller. The microcontroller used in this project is from 8051 family. Push buttons are provided for the operation of the motor which are interfaced to the microcontroller that provides an input signal to it and controls the speed of the motor through a motor driver IC. The speed and direction of DC motor has been observed on digital CRO. Microcontroller programming has been written in assembly language by using notepad and it has been converted in hex file by using micro vision Kiel. The burning of programming in the 8051 microcontroller chip has been done by using positron boot loader software.

Keywords: DC motor, AT89S52 Microcontroller, Motor Driver (L293D), Voltage Regulator (LM7805), Push Buttons, PWM.

I. INTRODUCTION

DC machines play a very important role in industries and in our daily life. The outstanding advantage of DC machines is that they offer easily controllable characteristics. This paper is designed to develop a four quadrant speed control system for a DC motor using microcontroller. The motor is operated in four quadrants i.e. clockwise, counter clock-wise, forward brake and reverse brake. It also has a feature of speed control.

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II. METHODOLOGY

The project work has been divided into two parts. In the first part simulation is done using proteus software and in second part a prototype model is developed and the result is verified using a prototype hardware model.

A. System Overview

The design was broken down into different modules to simplify the circuit design. Figure1 describes the block diagram of overall system for the four quadrant speed control of dc motor.
The circuit uses standard power supply comprising of a step down transformer from 230V to 12V and the four diodes forming a bridge rectifier that delivers pulsating dc which is unregulated is regulated to constant 5V dc. The output of the power supply which is 5V is connected to the 40pin of microcontroller and ground is connected to 20pin. Pin no 1 to 7 of port 1 are connected to switches. Pin no 21, 22, 23 of microcontroller are connected to input 1, 2, enable pins of motor driver L293D. Pin 3 and 6 are connected to motor terminals.

**B. Four Quadrant Operation of DC Motor:**

There are four possible modes or quadrants of operation using a DC Motor which is depicted in Figure 2. When DC motor is operating in the first and third quadrant, the supplied voltage is greater than the back emf which is forward motoring and reverse motoring modes respectively, but the direction of current flow differs. When the motor operates in the second and fourth quadrant the value of the back emf generated by the motor should be greater than the supplied voltage which are the forward braking and reverse braking modes of operation respectively, here again the direction of current flow is reversed.

**C. Pulse Width Modulation:**

Pulse width Modulation (PWM) is the term used to describe using a digital signal to generate an analogue output signal. PWM is one of the powerful techniques used in control systems today. This is usually used to control the average power to a load in a motor speed control circuit. It is used in wide range of application which includes: speed control, power control, measurement and communication.
Pulse-width modulation (PWM) is a commonly used technique for controlling power to an electrical device, made practical by modern electronic power switches. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast pace. The term duty cycle describes the proportion of on time to the regular interval or period of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on.

The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM works also well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle. PWM has also been used in certain communication systems where its duty cycle has been used to convey information over a communications channel. The duty cycle determines the speed of the motor. The desired speed can be obtained by changing the duty cycle. The PWM in microcontroller is used to control the duty cycle of DC motor. The PWM pulses generated from the microcontroller are viewed for various duty cycles in the simulation done in proteus software.

**D. Motor Driver IC:**
L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.

L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively. Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

**III. COMPLETE DRIVE SYSTEM**

To implement this project work three software have used. These are:

1) Kiel
2) Proteus
3) Flash Magic

**A. Kiel:**
Kiel compiler has been used to convert high level language into Hex code.

**B. Proteus:**
It has been used to simulate the result in software.

**C. Positron Boot Loader:**
It has been used to burn Hex code into microcontroller

The overall block of the system is implemented in the proteous software and the response and the operation of the motor is viewed as in figure 3.

![Fig. 3: System Tested In Software](image-url)
The response of the motor connected can be seen visually according to the program fed into the microcontroller and the operations are carried accordingly. It is the easiest way to check whether the hardware will get the desired output. The changes can be made to get the desired output and the operation can be carried out accordingly.

IV. HARDWARE DESCRIPTION

The following procedures are carried out for the four quadrant DC motor speed control operation using microcontroller. Here seven switches are interfaced to MC to control the speed of motor in four quadrants. When start switch is pressed the motor starts rotating in full speed being driven by a motor driver IC L293D that receives control signal continuously from the microcontroller. When clockwise switch is pressed the motor rotates in forward direction as per the logic provided by the program from the microcontroller to the motor driver IC. While forward brake is pressed a reverse voltage is applied to the motor by the motor driver IC by sensing reverse logic sent by the microcontroller for a short time period due to and reverse brake switch is pressed the microcontroller delivers a logic to the motor driver IC that develops for very small time a reverse voltage across the running motor due to which instantaneous brake situation happens to the motor. PWM switch is used to rotate the motor at varying speed by delivering from the microcontroller a varying duty cycle to the enable pin of the motor driver IC. It starts from 100% duty cycle and reduces in steps of 10% when it is pressed again and finally reaches to 10% duty cycle and the process repeats. Stop button is used to switch OFF the motor by driving the enable pin to ground from the microcontroller command accordingly.

V. PRACTICAL IMPLEMENTATION

The practical implementation of the four quadrant control of the DC motor is shown in figure 4. The hardware is designed and the operation has been done based upon the program written in the microcontroller for the four quadrant operation of the DC motor and the speed is also controlled by using PWM technique which instantaneous brake situation is applied to the motor.

Fig. 4: Complete Prototype Hardware Model

Similarly when motor is rotating in anti-clockwise direction by appropriate logic from the microcontroller to the motor driver IC.
VI. EXPERIMENTAL RESULTS

A. Simulation Results Using Proteus Software:
The simulated waveform of microcontroller based dc motor speed control for the four quadrant modes of operation i.e. clockwise, anticlockwise movement, forward and reverse braking is given below.
Fig. 6: (B). Waveform Of Anti-Clockwise Movement Of DC Motor

Fig. 6: (C). Waveform Of Forward Braking Of DC Motor

Fig. 6: (D). Waveform Of Reverse Braking Of DC Motor
Hardware Implementation:
The hardware model has been designed and implemented for speed control of dc motor using AT89S52 microcontroller and the waveform of input pulse given to dc motor from pin of microcontroller has been observed on digital CRO. And the waveforms for four quadrant modes of operations are achieved for different duty cycle achieved.

Fig. 6: (E). Clockwise Movement Of DC Motor

Fig. 6: (F). Anti-Clockwise Movement of DC Motor
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From the table no.01, it has been observed that as the duty cycle of dc motor increases its speed also increases.

1) By using PWM method the average power delivered to a load and speed of the DC Motor can be easily controlled. As the width of pulse varies, average voltage applied to motor varies and so the speed of dc motor also varies.

### Table - 1

<table>
<thead>
<tr>
<th>RPM</th>
<th>Duty cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clockwise</td>
</tr>
<tr>
<td>500</td>
<td>94.7%</td>
</tr>
<tr>
<td>1000</td>
<td>96.1%</td>
</tr>
<tr>
<td>1500</td>
<td>98.1%</td>
</tr>
<tr>
<td>2000</td>
<td>98.5%</td>
</tr>
</tbody>
</table>

Fig. 6: (g). Waveform of Forward Braking

Fig. 6: (h). Waveform of Reverse Braking
2) In this project the DC Motor is interfaced with AT89S52 Microcontroller using L293D Motor Driver. Push Button switches are provided to control the speed of the dc motor. The average DC value delivered to motor can be varied by varying the duty ratio of the PWM.

3) From the experiment it has been observed that in forward and reverse braking mode the dc motor runs for a short duration and after this it stops.

VII. CONCLUSION

The prototype hardware model for the four quadrant dc motor speed control using microcontroller is designed. A simulated model has been developed by proteus software and then result has been verified using a prototype hardware model. In the proposed model, the PWM technique has been used to control the speed of dc motor. By variation in duty cycle, applied voltage varies therefore speed of dc motor can be controlled. The waveform of input pulse given to DC motor has been taken for different values of duty cycle and it has been observed that speed of dc motor is directly proportional to duty cycle, i.e. as the on time duty cycle increases the speed of dc motor also increases. The waveform of input pulse of dc motor has been taken for forward and reverse braking mode and it has been observed that amplitude of waveform became high for very short duration and after that amplitude becomes zero.

In the experimental result it has been observed that some harmonics are occurred. It is due to different nonlinear electronic components such as diodes, transistors etc. present in the prototype developed model. It has been observed that amplitude of waveform obtained in proteus simulated model is 5v while it is 3.5v for waveform obtained from experimental result i.e. amplitude of waveform obtained from experimental result is less. It is due to the fact that some voltage drop has been taken place across resistors used in the prototype developed model.

It is practical and highly feasible in economic point of view and has an advantage of running motors of higher ratings. It gives a reliable, durable, accurate and efficient way of speed control of a DC motor. The program is found to be efficient and the results with the designed hardware are promising. The developed control and power circuit functions properly and satisfies the application requirements. The motor is able to operate in all the four quadrants successfully. Regenerative braking is also achieved.

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REFERENCES