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FOUR QUADRANT DC MOTOR CONTROL WITH CONTROLLER

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***Abstract* --- In this paper a four quadrant speed control system for DC motor has been designed, constructed and tested. The main advantage in using a DC motor is that the Speed-Torque relationship can be varied to almost any useful form. To achieve the speed control, an electronic technique called Pulse Width Modulation is used which generates High and Low pulses. These pulses vary the speed in the motor. For the generation of these pulses a microcontroller is used. As a microcontroller is used setting the speed ranges as per the requirement is easy which is done by changing the duty cycles time period in the program. Different speed grades and the direction are depended on different buttons. Experiment have proved that this system is of higher performance.**
Keywords--- AT89S51; DC motor; PWM

I. INTRODUCTION

In recent years, with scientific and technological progress and social development, the electronic technology is developing rapidly, to achieve the portability and low cost and energy efficient, and the noise limit, a DC motor is used widely, so, the study of DC motor speed adjustable is more practical significance. 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 as 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.

II. METHODOLOGY

The traditional method of control speed was that the resistance is strung in the rotor circuit or adjust the voltage of electrical machinery circuit, the two methods is easy, but they exist some shortcomings: The smooth character is bad and the characteristic is soft in low speed, The motor speed will be changed larger when the load is changed; The motor speed is very hard to get a low when the load is light the Efficiency reduce noticeably. Therefore, a new kind of speed control method is called PWM (pulse width modulation) speed regulating system has been widely used in the motor control speed.

With the wide use of PWM technological, the power energy can make full use of and the circuit efficient is very high. This paper utilizes the timing of the microcontroller timer function, outputs analog PWM signal at the P1.0 pin, to adjust the duty cycle according to the number of different pulse high, thus to achieve the governor’s role.

A. System Overview

The design was broken down into different modules to simplify the circuit design. Figure1 describes the overall system design for the four quadrant speed control of dc motor.

Figure1. Block diagram of the system The circuit uses standarad 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 Figure2 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

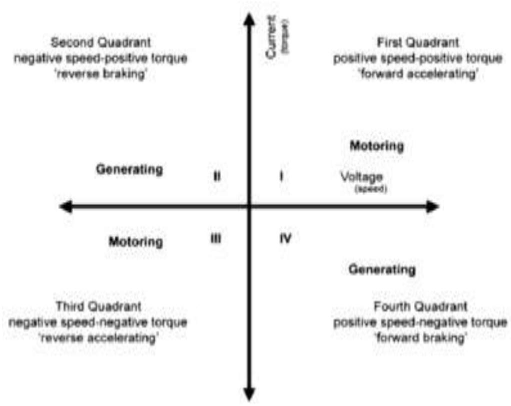

Figure 2. Four quadrants of operation

C.Pulse Width Modulation

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 longer the switch is on compared to the off periods, the higher the power supplied to the load is. 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 proteous software.

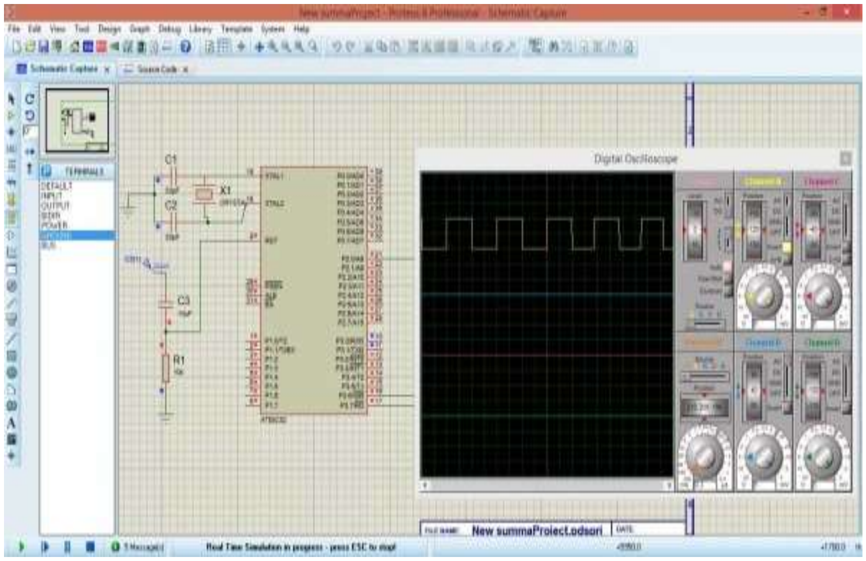

Figure 3. For 50% duty cycle

Average voltage = D * Vin

(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.

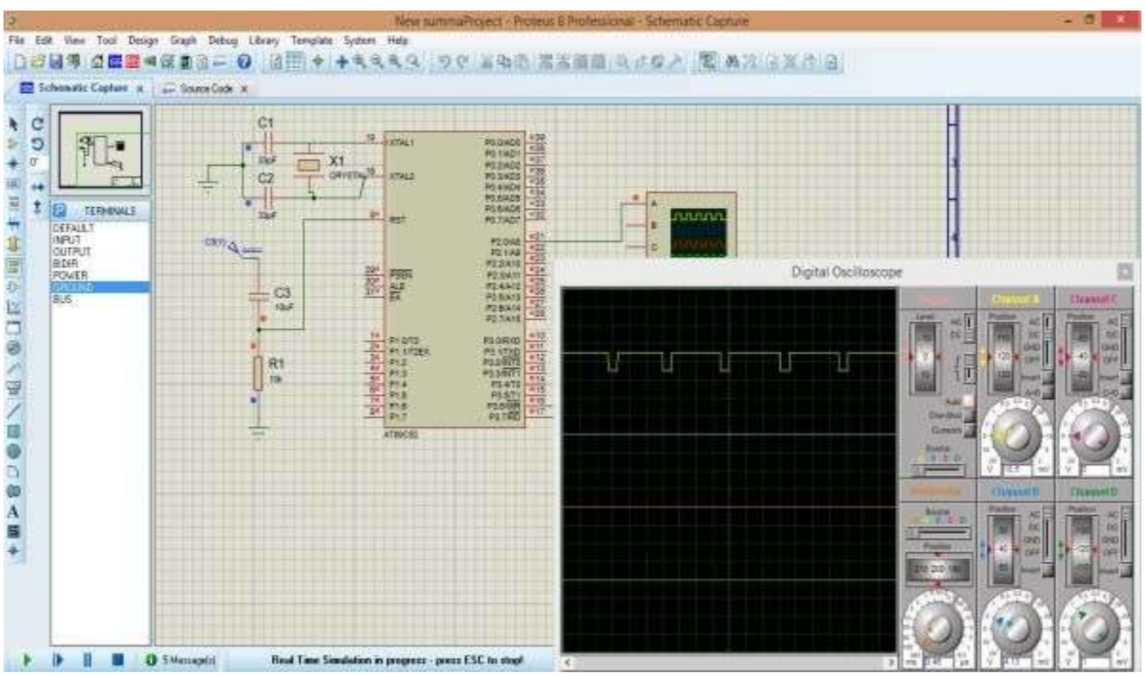

Figure 4. For 80% duty cycle

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

III. COMPLETE DRIVE SYSTEM

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 5.

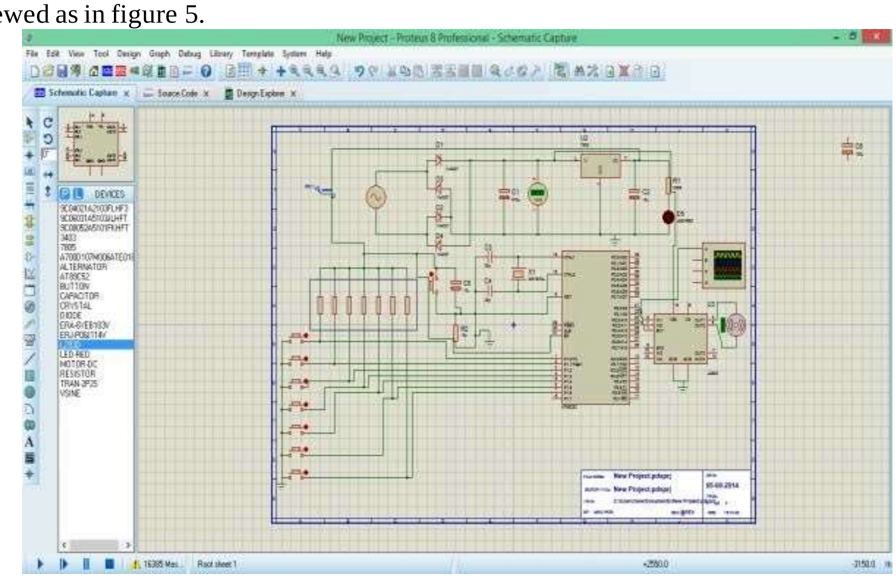

Figure 5. System tested in software

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 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.

III. PRACTICAL IMPLEMENTATION

The practical implementation of the four quadrant control of the DC motor is shown in figure 6. 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

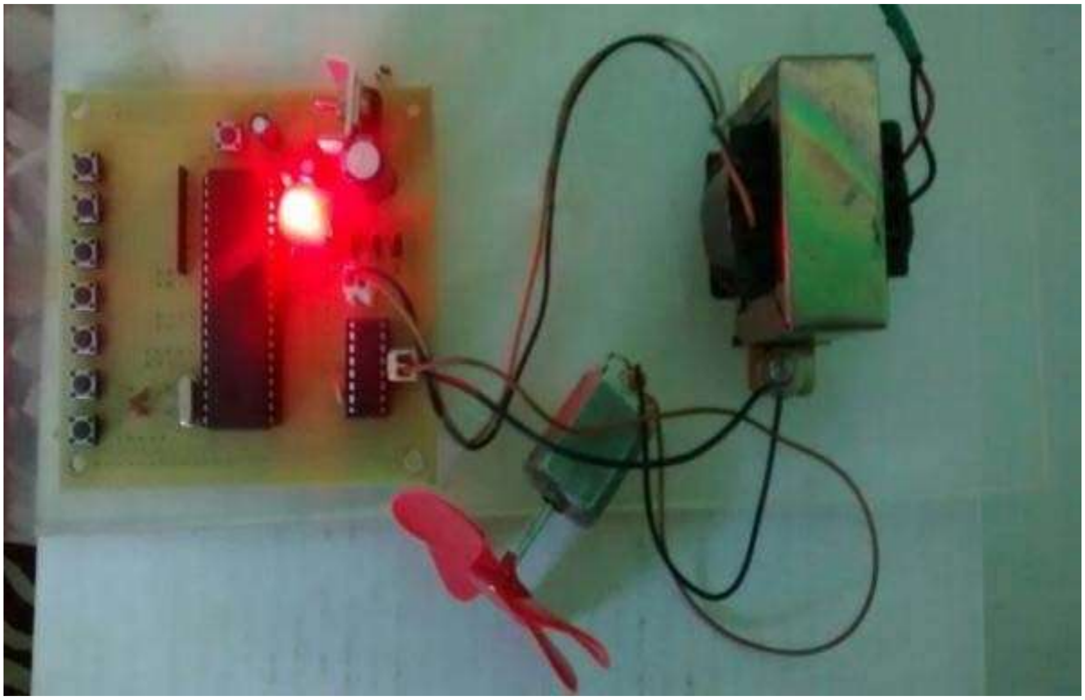

Figure 6. Practical Implementation

which instantaneous brake situation is applied to the motor. Similarly when motor is rotating in anti-clockwise direction by apprpriate logic from the microcontroller to the motor driver IC

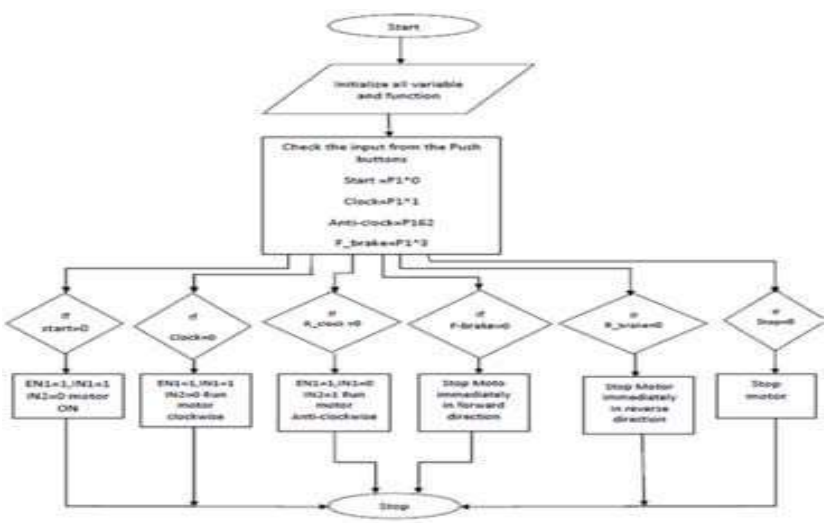

Figure 7. Flow chart for operation of DC motor

VI . CONCLUSION

The hardware for four quadrant dc motor speed control using microcontroller is designed. It is proved to be operated so simple. 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. Simulation and experimental results tally with each other and justify effectively the developed system. Further this four quadrant speed control system of a DC motor will be implemented in dSPACE in real time and its responses will be viewed.

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