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FOUR QUADRANT DC MOTOR SPEED CONTROL USING ARDUINO

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Abstract- The project is designed to develop a four-quadrant speed-control system for a DC motor. The motor is operated in four quadrants: 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 according to the requirement. They can rotate in clockwise, counter-clockwise directions and also one can 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 a 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 PWM pulses generated by the Arduino Board. Arduino Development Board is used for this operation. Push buttons are provided for the operation of the motor which are interfaced to the Arduino that provides input signal to it and in turn controls the speed of the motor through a motor driver IC. Speed control feature by push-button operation is also available in this project

Keywords-DC motor, Arduino,Power supply block,L293D Motor driver IC, Speed control, 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 Arduino. In this work the concept of four quadrant speed control i.e. clockwise movement, anticlockwise movement, instantaneous forward braking and instantaneous reverse braking of a dc motor with the help of Arduino through motor driver (L293D) has been proposed.

The same application is used in many areas such as to control the rudder of aeroplane, electric bicycle or an electric car. The motor is built from a stationary magnet and rotating coils. The brushes supply electric current to the coil that is close to the motor magnet pole pieces .As the rotor turns, the polarity of each coil is reversed and sustained rotation of motor is achieved. The direction of rotation depends on the polarity of brushes. The torque applied on the rotor depends on the current passing through the coils. The steady speed depends on the current flowing through the coils and load being driven by the motor.

II. BLOCK DIAGRAM AND CIRCUIT DIAGRAM DESCRIPTION

Figure-1 shows the block diagram of the project. 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 Arduino and motor driver IC. Control is given through the switch array to the Arduino and further to the motor driver IC which controls the speed of the DC motor.

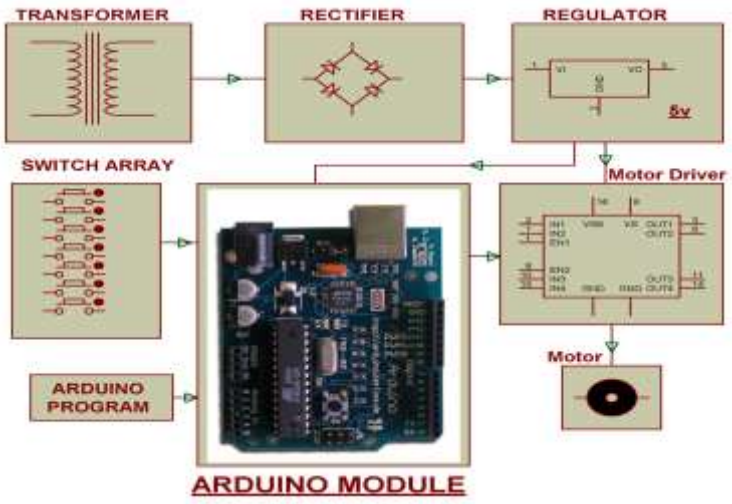

Fig. 1. Block Diagram of Four Quadrant DC Motor Speed Control By Using Arduino

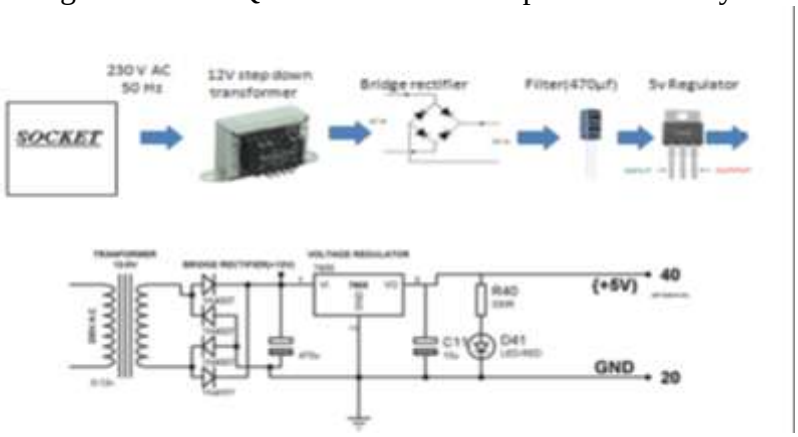

Fig. 2. Circuit Diagram of Power Supply Block of Four Quadrant DC Motor Control

III. METHEDOLOGY

The total project consists of four sections i.e

A. System Overview
B. Four Quadrant Operation of DC motor
C. Pulse Width Modulation
D. Motor Driver IC

A. System Overview

The design was broken down into different modules to simplify the circuit design. Figure 3 describes the block diagram of overall system for the four quadrant speed control of dc motor.

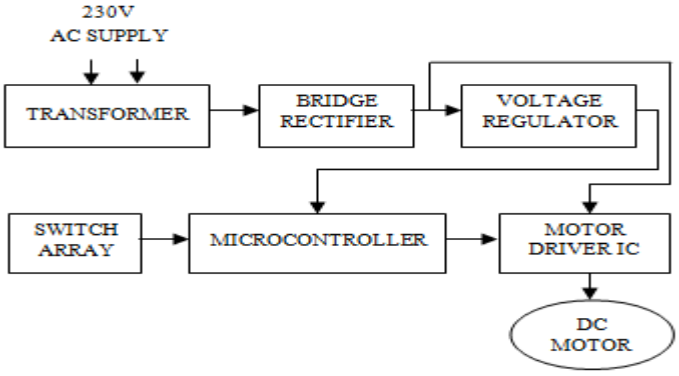

Fig. 3. Block Diagram of The System

B. Four Quadrant Operation of DC Motor:

The motor is operated in four quadrants: clockwise, counter clock-wise, forward brake and reverse brake. Motor action converts the electric energy into mechanical energy and it produces forward motion, hence it called as motoring action, whereas braking action converts mechanical energy to electrical energy which gives forward braking motion, it is termed as generator. There are four possible modes or quadrants of operation using a DC Motor which is depicted in Figure 3. 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.

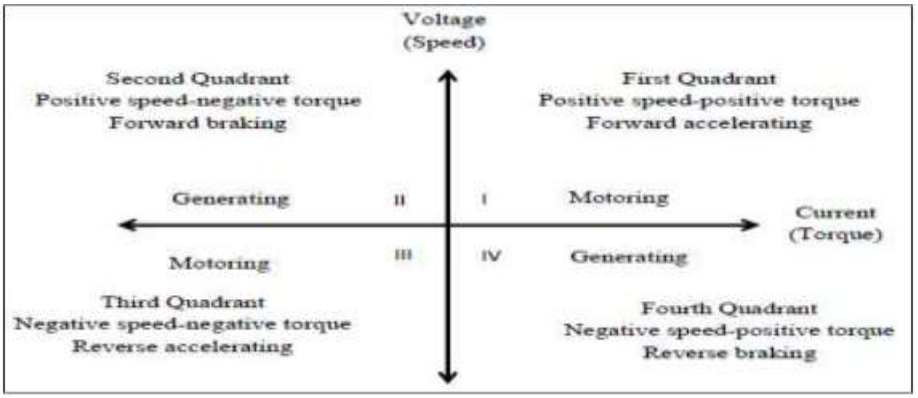

Fig. 4. Four Quadrant Operation of a DC Motor

C. Pulse Width Modulation

Pulse width Modulation (PWM) is the term used to describe using a digital signal to generate an analog 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 main advantage of PWM is that power loss in the switching devices is very low.

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. 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.

IV. RESULTS AND DISCUSSION

The practical implementation of the four quadrant control of the DC motor is shown in figure 5. The hardware is designed and the operation has been done based upon the program written in the Arduino 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. The project model is supplied with 230V ac supply from the circuit. The 230V supply is given to the primary of the transformer which gives 12V output. This 12V ac supply fed to bridge rectifier, which converts it into 12V dc. This 12V dc is given to voltage regulator which provides 5V dc.

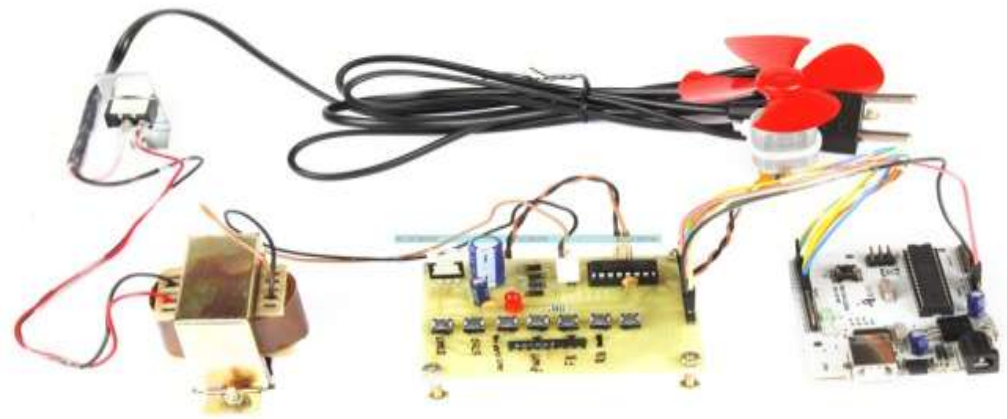

Fig. 5. Practical Implementation of Speed Control Dc Motor

The output of the power supply which is 5V, is connected to Arduino and motor driver IC. Control signal is given through the switch array to the Arduino and further to the motor driver IC which controls the speed of the DC motor.

V. CONCLUSION AND FUTURE APPLICATIONS

The hardware for the four quadrant dc motor speed control using Arduino is designed. It is proved to be operated so simple. In the proposed model, we have used Arduino which generates PWM signal. 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.

This project 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 Arduino program is found to be simple, 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. This project can be enhanced by using higher power electronic devices to operate high capacity DC motors

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