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

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ABSTRACT

The main aim to design this paper is to develop a four quadrant speed control of a DC motor with the help of the microcontroller. The most important part of any industrial organization is to control the speed of a machine. 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 of the motor. For the generation of these pulses a microcontroller is used. As a microcontroller is used to set 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. 8051 families microcontroller used in this project and programming has been written in assembly language, then converted into hex file by using micro vision Kiel software. The burning of the program in the microcontroller has been done by using positron boot loader software.

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

I.INTRODUCTION

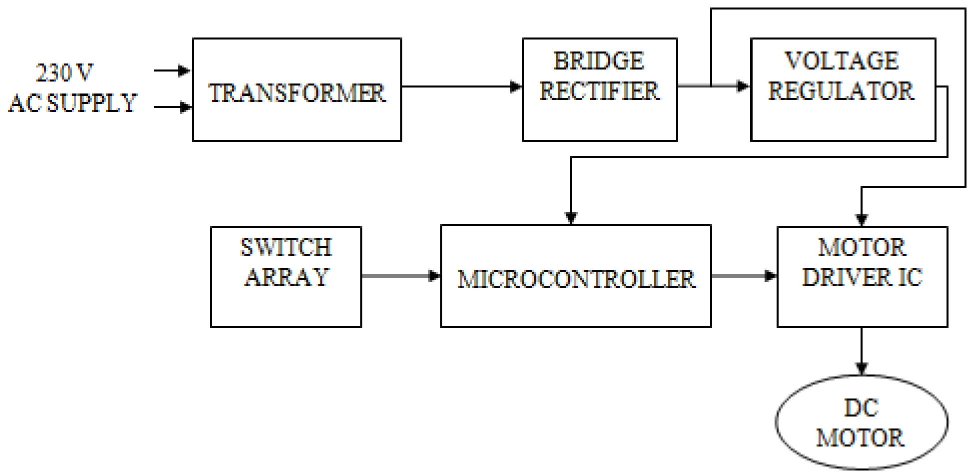
In recent years, with scientific and technological progress and social development, the electronic technology is developing rapidly, to achieve the portability and low cost and energy efficient, and the noise limit, a DC motor is used widely, so, the study of DC motor speed adjustable has more practical significance. The motor is operated in four quadrants i.e. clockwise; counter clockwise, forward brake and reverse brake.[2] 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.[2] In case of a specific operation in industrial environments, the motor needs to be stopped immediately. In such scenario, this proposed system is very apt as forward brake and reverse brake is its integrated features.[2] 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.[2]

II. OPERATION AND WORKING

The project work has been divided into two parts. In the first part simulation uses Proteus software and in the second part a prototype model is developed and after that the result is verified using a prototype hardware model.[3]

A. Block Diagram:

In this diagram, 230V AC supply is converted in 12V AC input supply then with the help of 4 diode bridge rectifier is form which convert AC supply into pulsating DC supply which is unregulated is regulated to constant 5V DC.[4] This 5V supply is connected to 40 pins of the microcontroller and ground is connected to 20 pins of the microcontroller. Pin no 1 to 7 of port 1 are connected to switches and pin no 21, 22, 23 of the microcontroller are connected to input 1,2, enable pins of motor driver L293D and pin 3 and 6 are connected to motor terminals.



"Fig. 1: Block Diagram of the System"

B. Four Quadrant Operation of DC Motor:

There are four possible quadrants of operation or modes using a DC Motor which is shown 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.[1] 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.[1]

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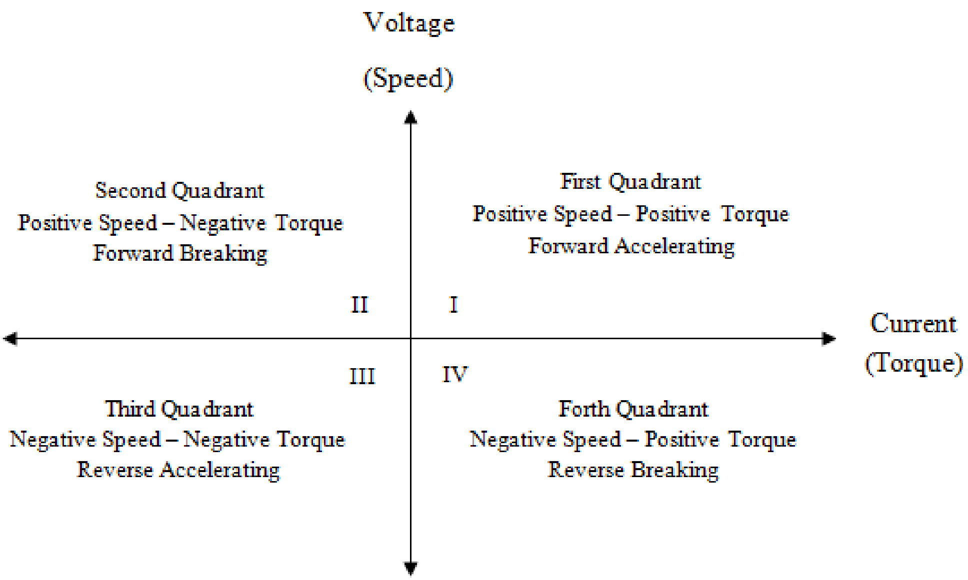

"Fig. 2: Four Quadrants of Operation"

C. Pulse width modulation:

Pulse width modulation (PWM) is a modulation technique used in most of the communication system for encoding the amplitude of a signal right into a pulse width or duration of another signal, usually a carrier signal, for transmission. The main purpose of PWM is actually to control the power that is supplied with various types of electrical devices, most especially with inertial loads such as AC/DC motors. Pulse-width modulation (PWM) or duty cycle variation methods are commonly used in speed control of DC motors. The duty cycle is defined as the percentage of digital 'high' to digital 'low' plus digital 'high' pulse-width during a PWM period. PWM is one of the powerful techniques used in control systems today.[4] This is usually used to control the average power to a load in a motor speed control circuit.[4] It is used in a wide range of application which includes: speed control, power control, measurement and communication.[6] The advantages of PWM are that you can control a traditionally analog load using a digital signal and a switching element. This means that digital systems such as programmable logic controllers, computers, microcontrollers, or a well-designed digital circuit with just gates can control a device designed to be powered by a constant voltage. In this sense, it's a form of digital to analog conversion. You can use it to modulate normally single-speed/power devices. You can operate a device above its normal maximum. You can respond much more quickly. If your controller gets a command to suddenly stop, you can set the pulse width to zero within a couple of cycles. This means very accurate control and dynamic response.

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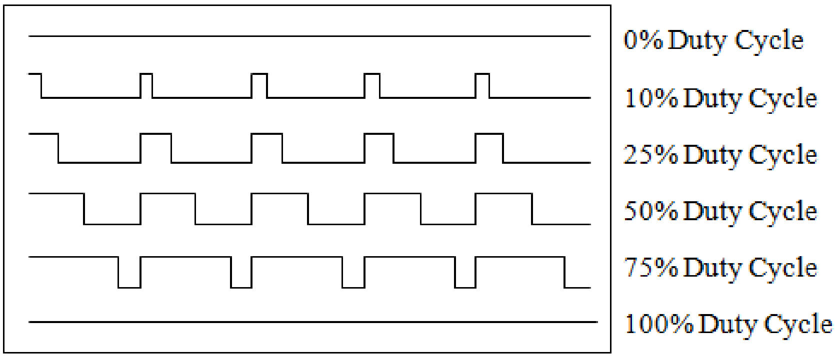
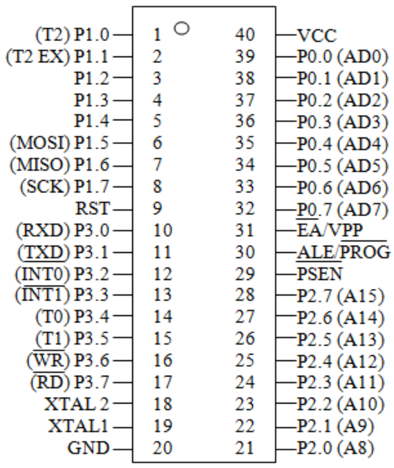


"Fig. 3: Duty Cycle"

D. Microcontroller:

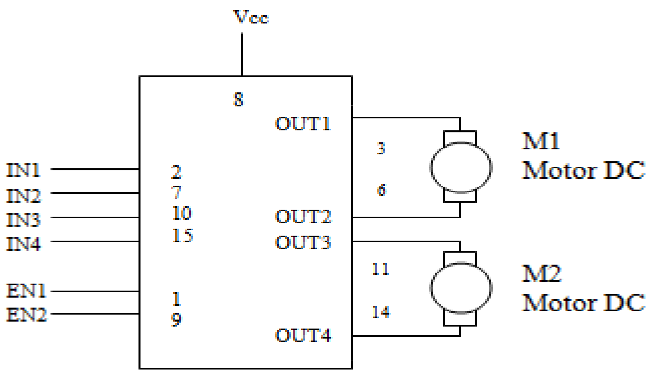
The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out.[7] The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer.[5] By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.[8] The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.[5] The microcontroller block is interfaced with DC motor using motor driver IC, the power supply block provides power supply to the project kit, and switch array. This switch array is used to send the control signals to the microcontroller which in turn sends commands to the motor driver IC for controlling the operation of the DC motor.



"Fig. 4: AT89S52 Microcontroller"

E. Motor Driver IC:

A motor drivers IC is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver ICs act as an interface between microprocessors in robots and the motors in the robot. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. Most microprocessors operate at low voltages and require a small amount of current to operate while the motors require a relatively higher voltage and current. Thus current cannot be supplied to the motors from the microprocessor. This is the primary need for the motor driver IC. The L293D IC receives signals from the microprocessor and transmits the relative signal to the motors. It has two voltage pins, one of which is used to draw current for the working of the L293D and the other is used to apply voltage to the motors. The L293D switches its output signal according to the input received from the microprocessor. For Example: If the microprocessor sends a 1(digital high) to the Input Pin of L293D, then the L293D transmits a 1(digital high) to the motor from its Output Pin. An important thing to note is that the L293D simply transmits the signal it receives. It does not change the signal in any case.



"Fig. 5: L293D Motor Driver IC"

III. COMPLETE DRIVE SYSTEM

The implementation of this project work requires three softwares. These are:

1. Kiel
2. Proteus
3. Positron Boot Loader

1. Kiel:

The main working of Kiel compiler is to convert the high level language into the Hex code.[1]

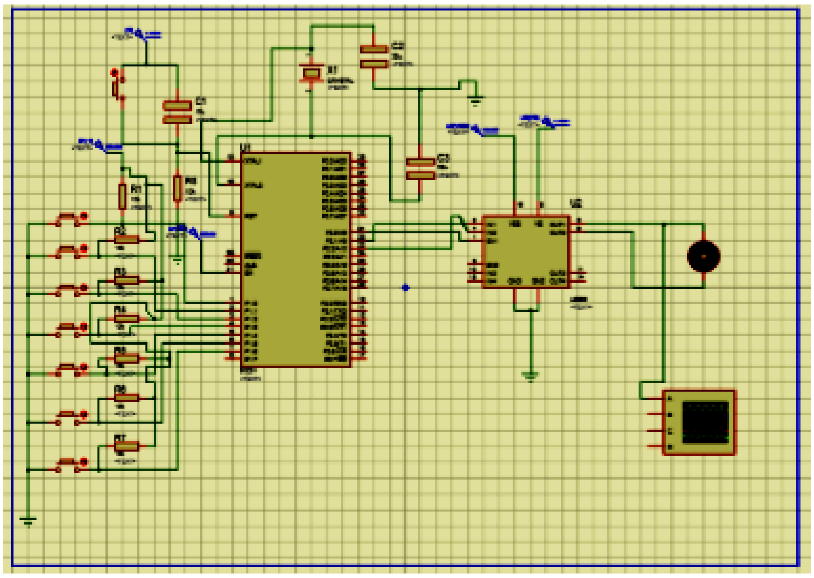
2. Proteus:

Proteus software is used to simulate the results in software.[1]

3. Positron Boot Loader:

Positron Boot Loader is used to burn Hex code into the microcontroller.[1]

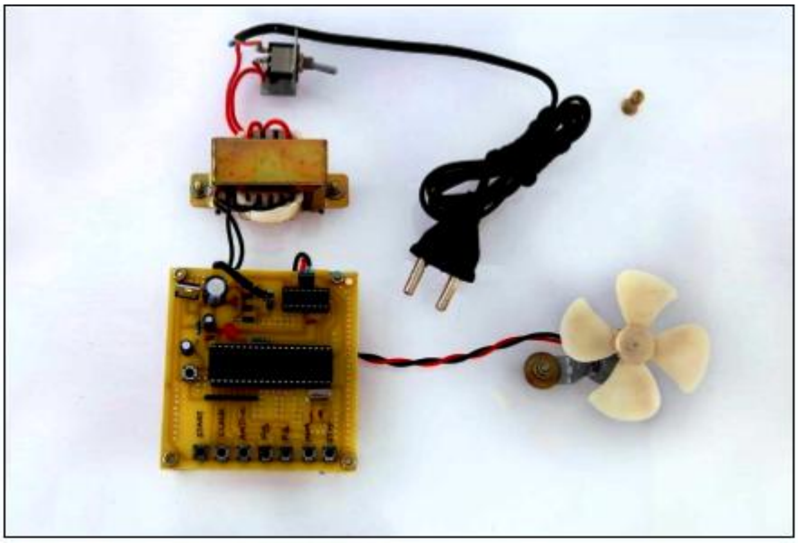
The response of the motor connected can be seen visually according to the program fed into the microcontroller and the operations are carried accordingly. It is the easiest way to check whether the hardware will get the desired output. The changes can be made to get the desired output and the operation can be carried out accordingly.[1]



"Fig. 6: System Tested In Software"

IV. HARDWARE DESCRIPTION

This circuit is used for the four quadrant DC motor speed control operation. Here seven switches are interfaced to microcontroller to control the speed of the motor.[1]



"Fig. 7: Complete Prototype Hardware Model"

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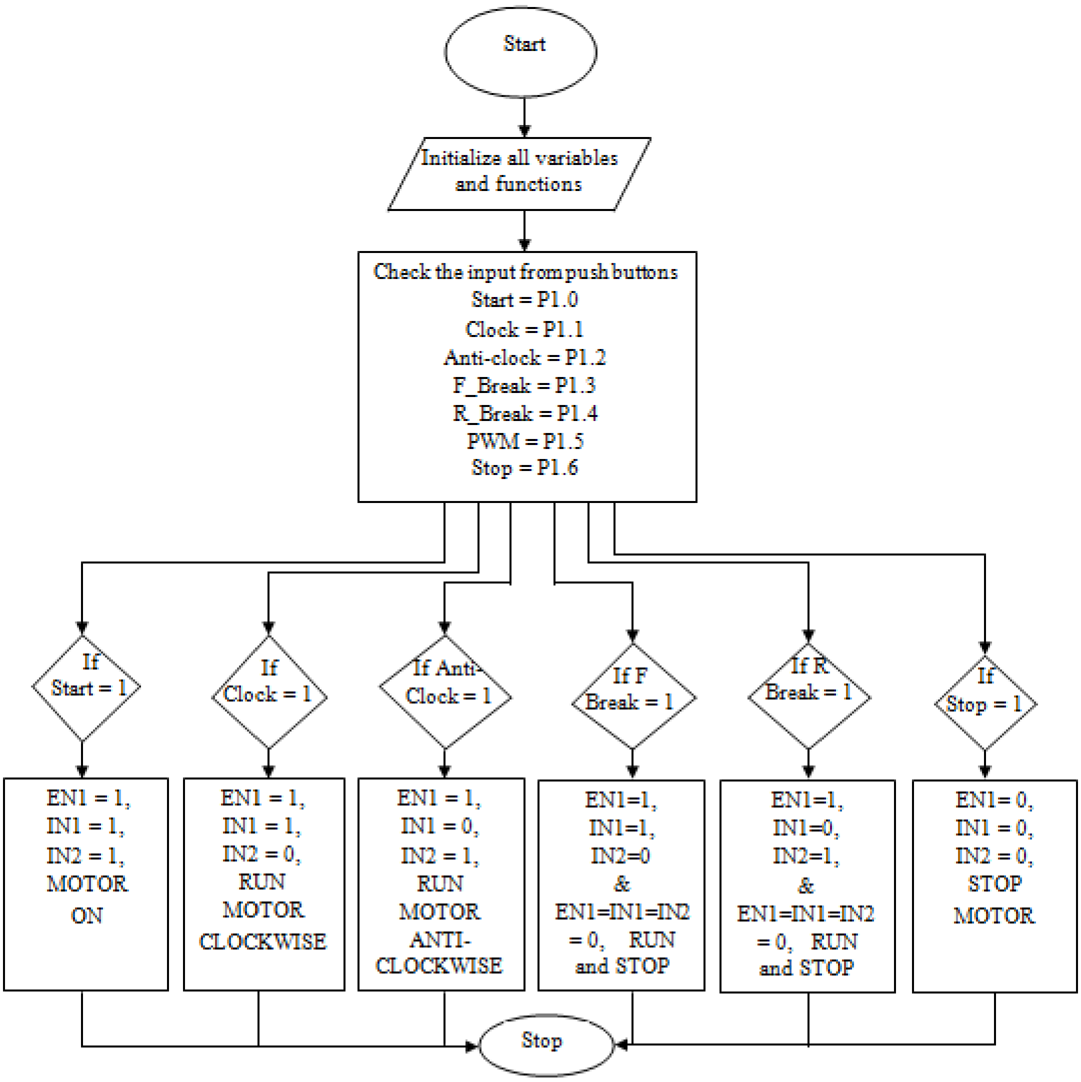
When the starting switch is pressed the motor starts rotating at full speed being driven by a motor driver IC L293D that receives control signal continuously from the microcontroller.[1] When clockwise switch is pressed the motor rotates in the forward direction as per the logic provided by the program from the microcontroller to the motor driver IC.[1] 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.[1] PWM switch is used to rotate the motor at varying speeds by delivering from the microcontroller a varying duty cycle to the enable pin of the motor driver IC.[1] 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.[1] Stop button is used to switch OFF the motor by driving the enable pin to ground from the microcontroller command accordingly.[1]

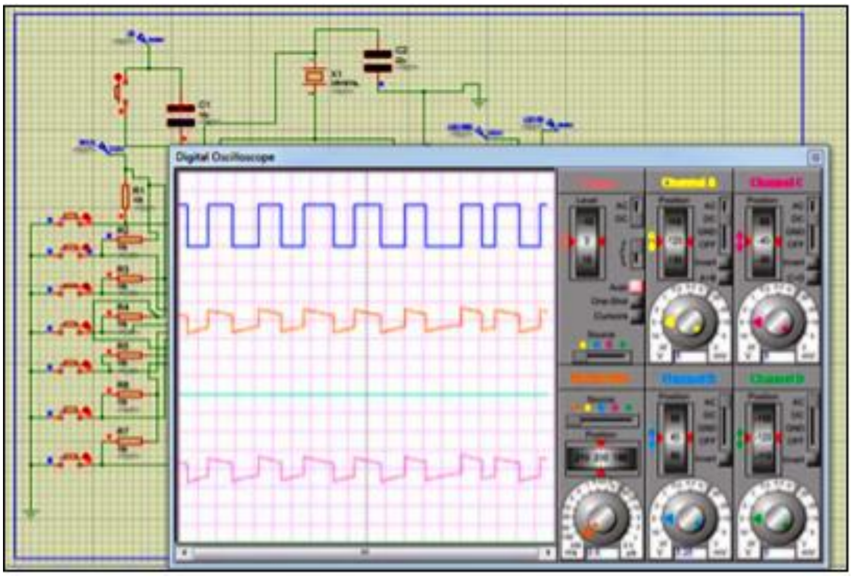


“Fig. 8: Flow Chart Diagram of System”

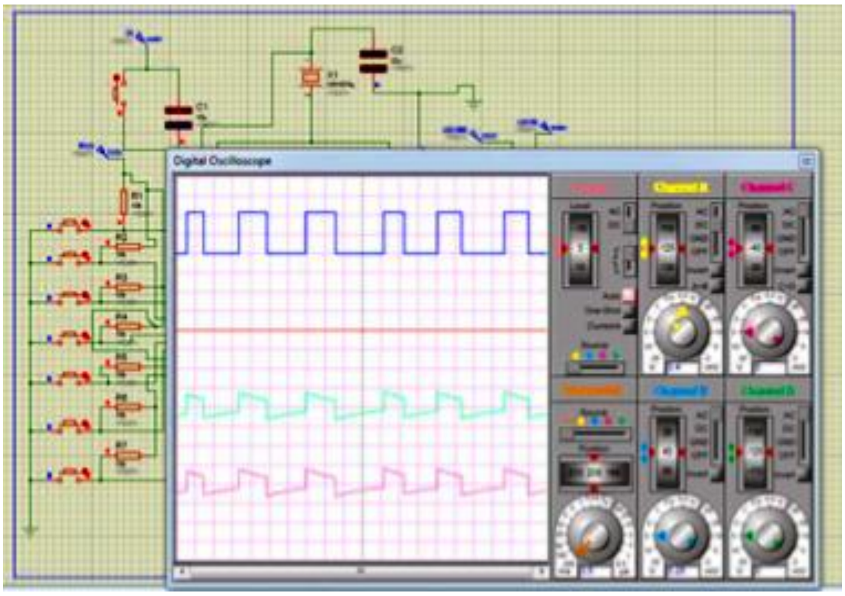
V. EXPERIMENTAL RESULTS

A. Simulation Results Using Proteus Software:

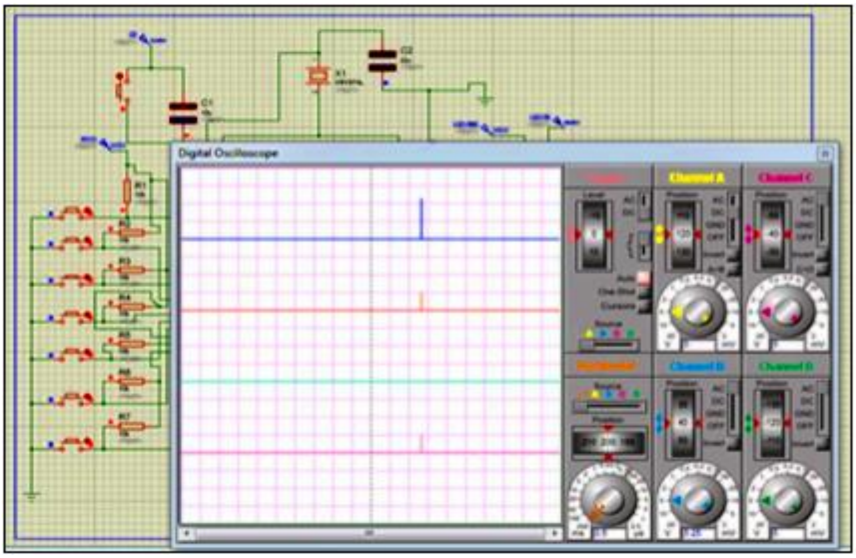
The simulated waveform of microcontroller based dc motor speed control for the four quadrant modes of operation i.e. clockwise, anticlockwise movement, forward and reverse braking is given below.



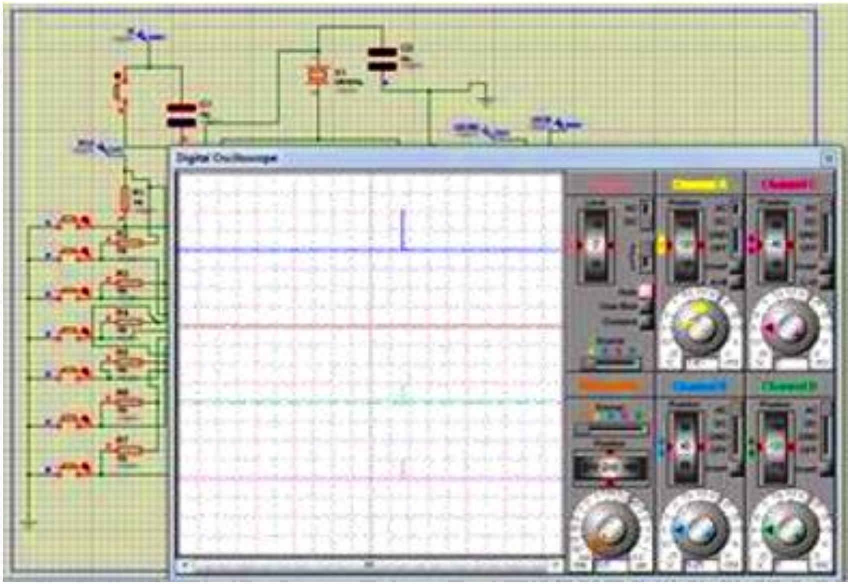
"Fig. 9: (A). Waveform of Clock-Wise Movement of Dc Motor"



"Fig. 9: (B). Waveform of Anti-Clockwise Movement of Dc Motor"



"Fig. 9: (C). Waveform of Forward Braking of Dc Motor"



"Fig. 9: (D). Waveform of Reverse Braking of Dc Motor"

B. Hardware Implementation:

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 cycles are:

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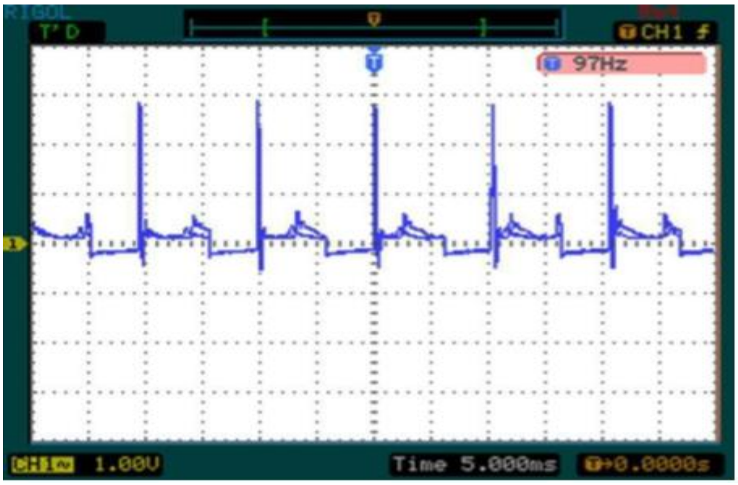
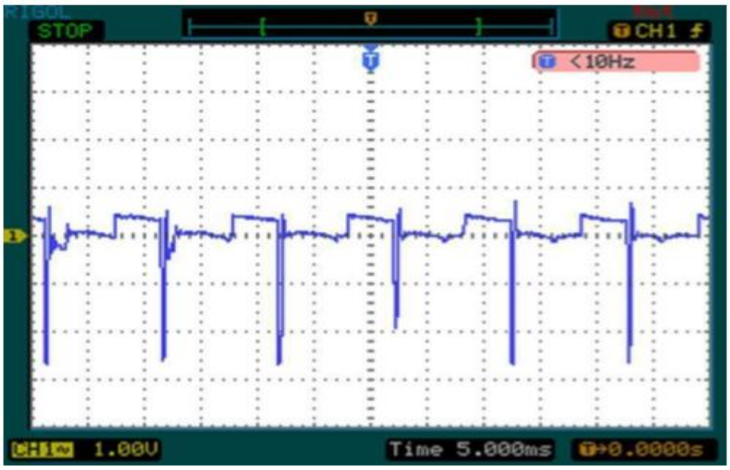
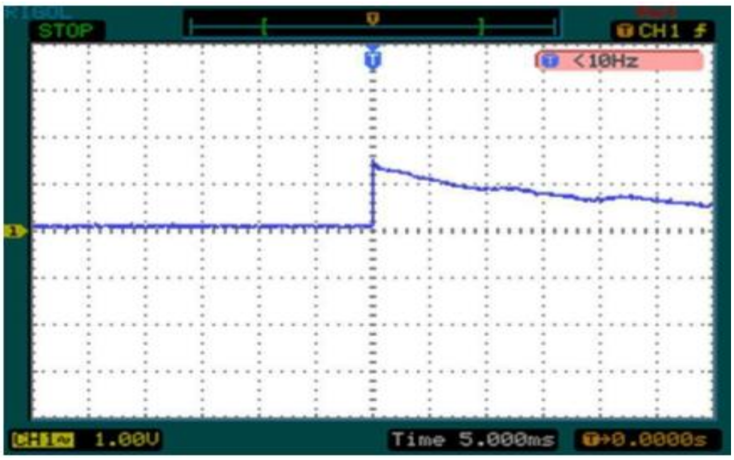


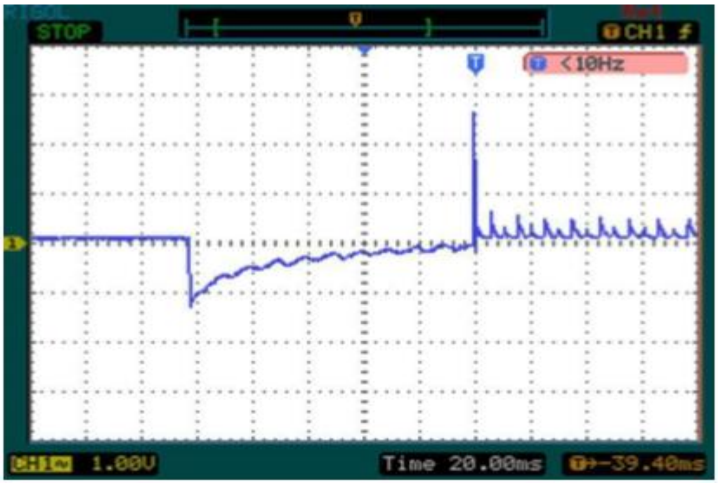
"Fig. 9: (E). Clockwise Movement of DC Motor"



"Fig. 9: (F). Anti-Clockwise Movement of DC Motor"



"Fig. 9: (G). Waveform of Forward Braking"



"Fig. 9: (H). Waveform of Reverse Braking"

VI. CONCLUSION

The hardware for four quadrant DC motor speed control using microcontroller is designed. 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.[4] By variation in duty cycle, applied voltage varies therefore the speed of DC motor can be controlled.[4] 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 one time duty cycle increases the speed of DC motor also increases.[4] The waveform of input pulse of DC motor has been taken for forward and reverse braking mode and it has been observed that the amplitude of waveform became high for very short duration and after that amplitude becomes zero.[4] In the experimental result, it has been observed that some harmonics are occurring. It is due to different nonlinear electronic components such as diodes, transistors etc.[4] present in the prototype developed model. It is proved to be operated so simply.[4] This project is practical and highly feasible in an economic point of view and it has an advantage of running motors of higher ratings.[4] It is good in terms of reliability and durability and also it gives an accurate and efficient way of speed control of a DC motor.[4] The program is found to be efficient and the results with the designed hardware are promising.[4] The developed control and power circuit functions properly and satisfies the application requirements.[4] The motor is able to operate in all the four quadrants successfully.[4] Regenerative braking is also achieved. Simulation and experimental results tally with each other and justify effectively the developed system.[4]

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