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Study of Four Quadrant Velocity Control System Based On Microcontroller for a Dc Motor

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ABSTRACT:
The main purpose of this paper is to create, with the aid of a microcontroller, a four-quadrant speed control of a DC motor. Any industrial organization has the most important part 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. Those pulses vary the engine speed. A microcontroller is used for the generation of those pulses. As a microcontroller it is simple to adjust the speed ranges according to the requirement by adjusting the length of the program's duty cycles. 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).

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I. INTRODUCTION

In recent years, with scientific and technological developments and social growth, electronic technology is rapidly evolving to achieve portability and low cost and energy efficiency, and a DC motor is commonly used as a noise limit, 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. It also has a feature of speed control. The DC motor's four quadrant operation is ideally suited for industries where motors are used and as needed, because they can rotate in the clockwise, counter-clockwise direction and also brake immediately in both directions. 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. Instant brake in both directions occurs as a result of applying a reverse voltage across the running motor for a brief period of time and the motor speed control can be accomplished with the microcontroller-generated PWM pulses.

II. OPERATION AND WORKING

Work on the project has been divided into two parts. Proteus software is used in the first part of the simulation and a prototype model is built in the second part and the result is then tested using a prototype hardware model.

i. Block diagram

In this diagram 230V AC supply is converted into 12V AC input supply then formed with the aid of 4 diode bridge rectifier which converts AC supply into pulsating unregulated DC supply is controlled to constant 5V DC. 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.

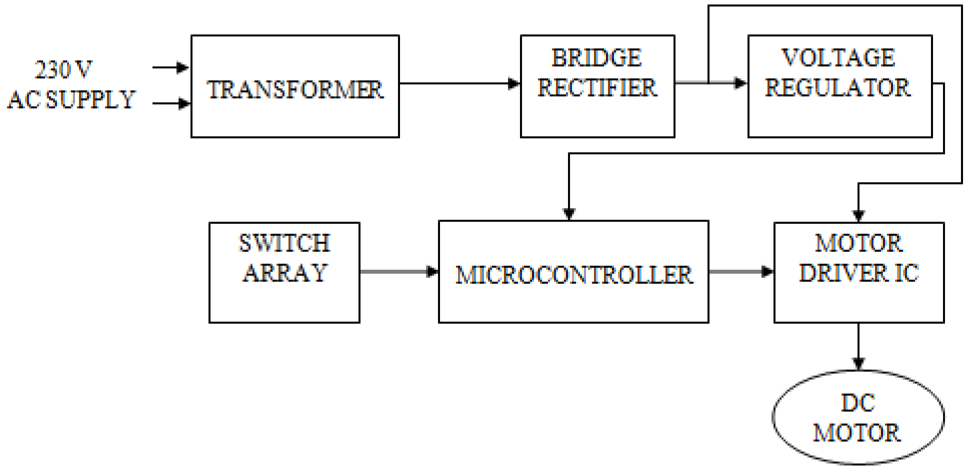


Fig.1: Block Diagram of the System

ii. Four Quadrant Operation of DC Motor:

There are four possible operating quadrants or modes using a DC Motor as shown in Figure 2. As DC motor works in the first and third quadrants, the voltage supplied is higher than the back emf which is motor mode forwards and reverse motor mode 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.

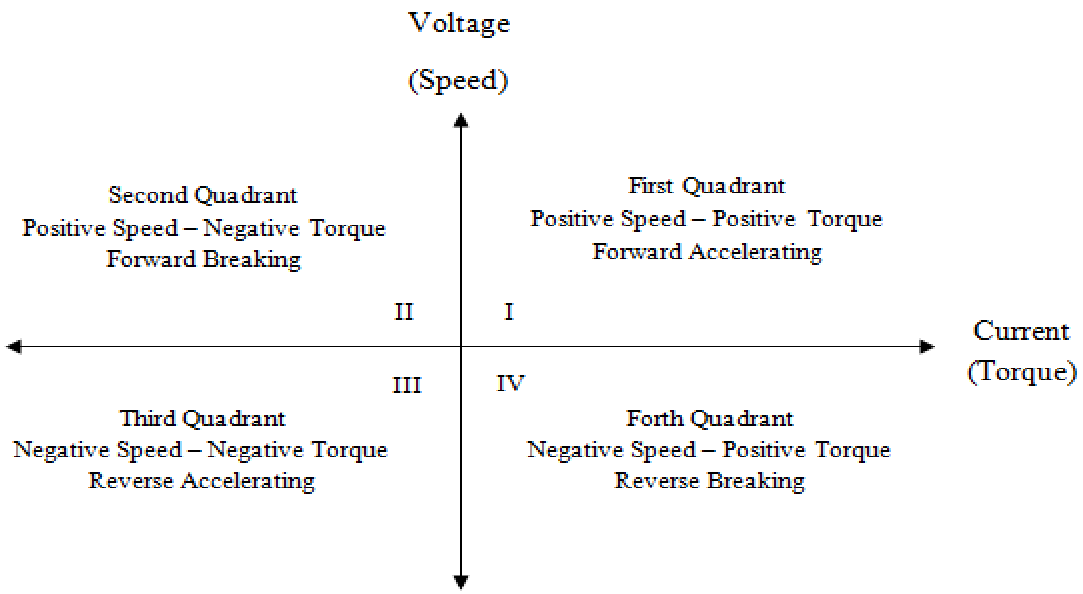


Fig.2: Four Quadrants of Operation

iii. Pulse width modulation:

Pulse width modulation (PWM) is a modulation technique that is used in most communication systems to convert the amplitude of a signal right into a pulse width or the length of another signal, normally a carrier, 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.

Usually this is used to control the average load power in a motor speed control circuit. It is used in a wide variety of applications including: speed control, power control, calculation, and communication. 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-built digital circuit with only gates can control a device designed to be controlled 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.

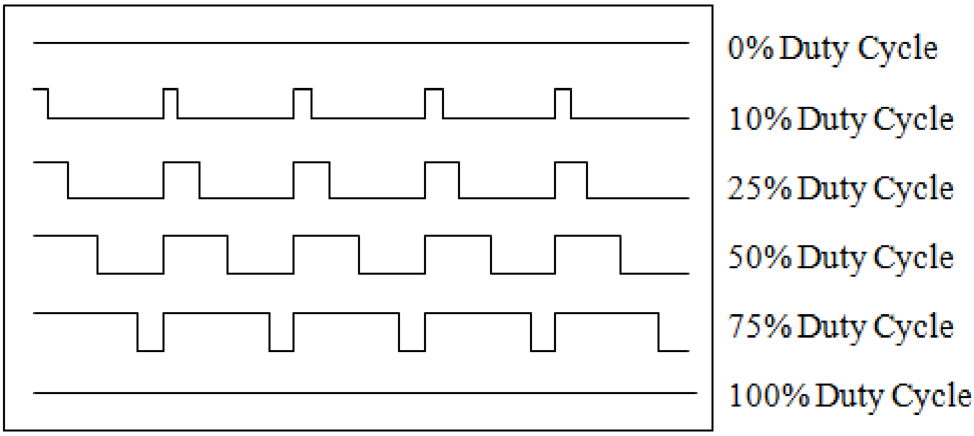


Fig.3: Duty Cycle

iv. Microcontroller:

The AT89S52 is a low-power, high-performance 8-bit CMOS microcontroller with 8 K bytes of Flash memory programmable inside the chip. The product is manufactured using the high-density, non-volatile memory technology from Atmel and is compliant with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. 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. The AT89S52 offers the following standard features: 8 K Flash bytes, 256 RAM bytes, 32 I / O lines, Watchdog timer, two data pointers, three 16-bit timer / counters, a two-level interrupt six-vector architecture, a full serial duplex port, on-chip oscillator and clock circuitry. 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 effect, sends commands to the driver IC to control the DC motor operation.

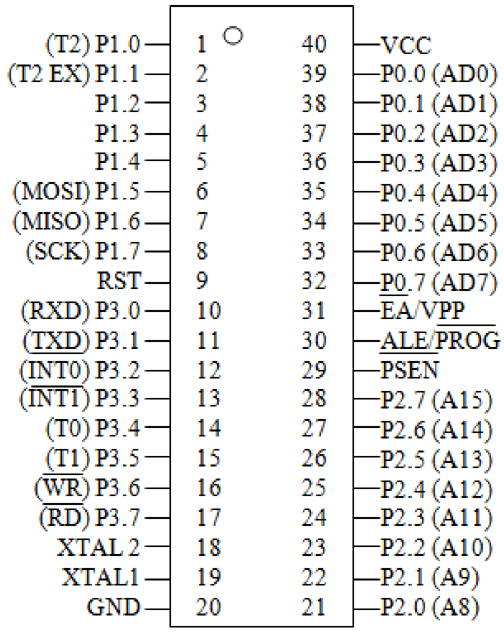


Fig.4: AT89S52 Microcontroller

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's the best way to test whether the hardware is getting the desired output. The changes can be made to get the desired output and the operation can be carried out accordingly.

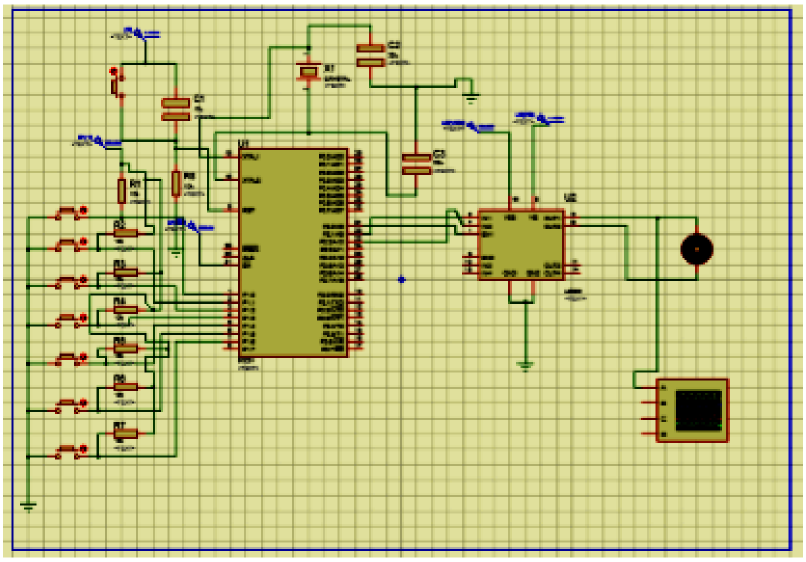


Fig.6: System Tested In Software

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.

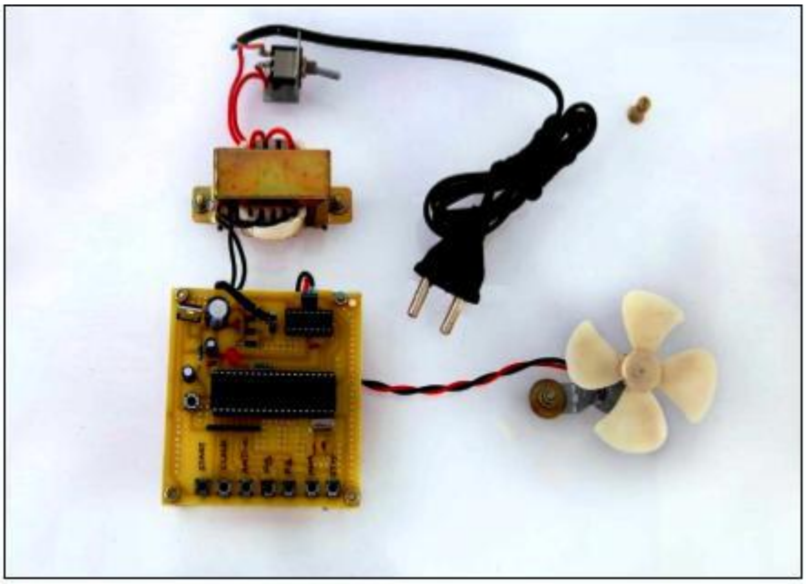


Fig.7: Complete Prototype Hardware Model

Once the starting switch is pressed, the motor begins to rotate at full speed and is powered by an IC L293D motor driver that receives continuous control signal from the microcontroller. 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. 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 engine at varying speeds by supplying a varying duty cycle from the microcontroller to the motor driver IC's allow button. This begins at 100% of the duty cycle and decreases by 10% when pressed again and finally reaches 10% of the duty cycle and the process repeats itself. Stop button is used to switch OFF the motor by driving the enable pin to ground from the microcontroller command accordingly.

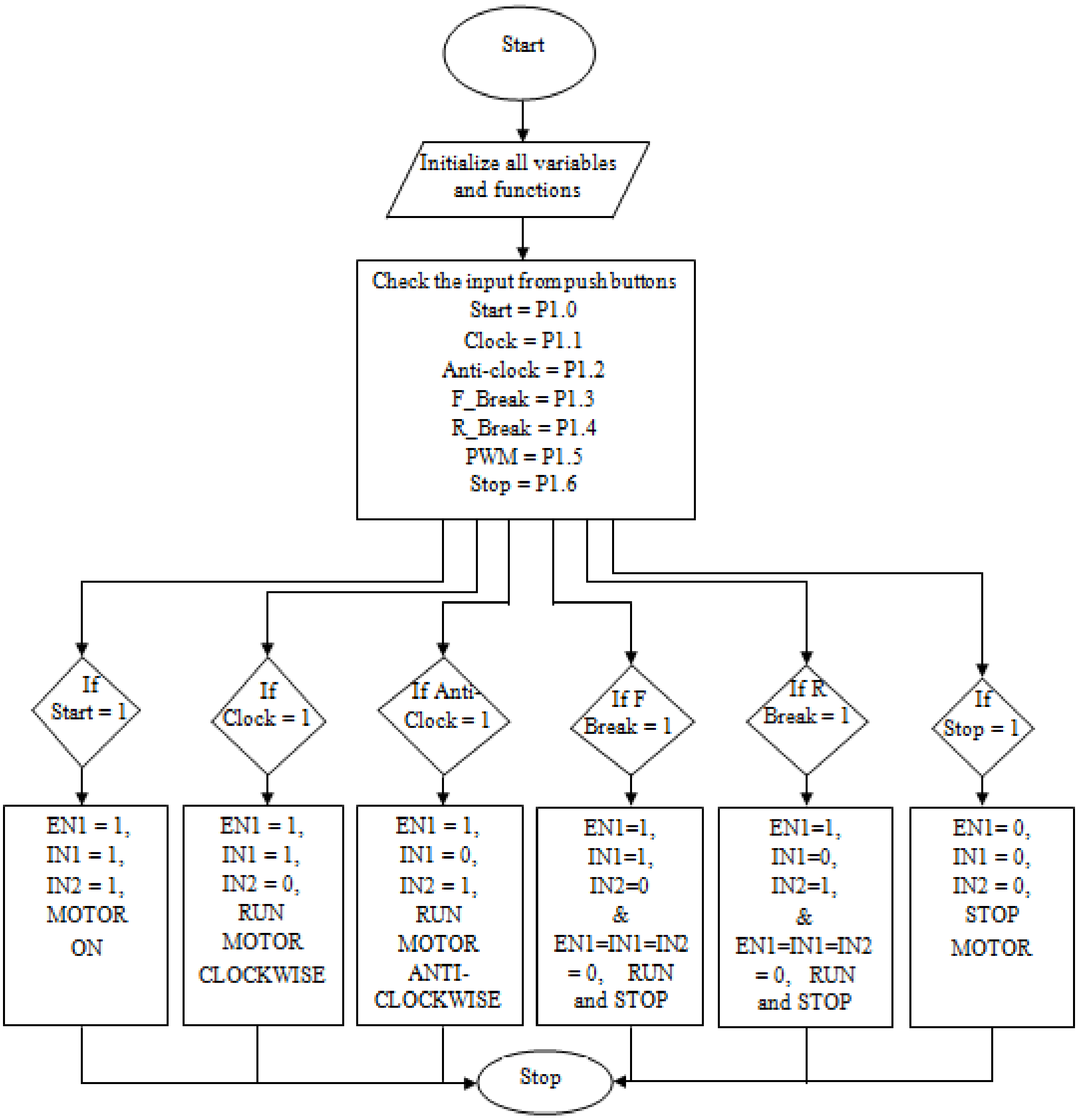


Fig.8: Flow Chart Diagram of System

V. EXPERIMENTAL RESULTS

i. 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.

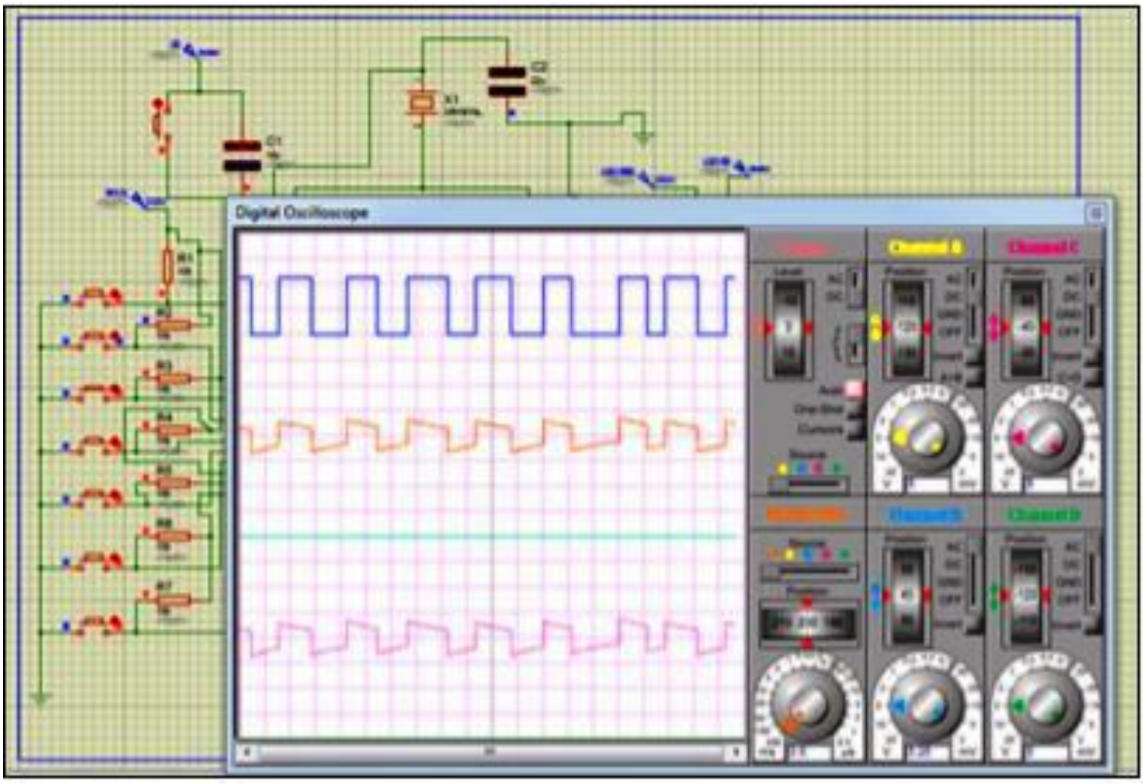


Fig.9: (A). Waveform of Clock-Wise Movement of Dc Motor

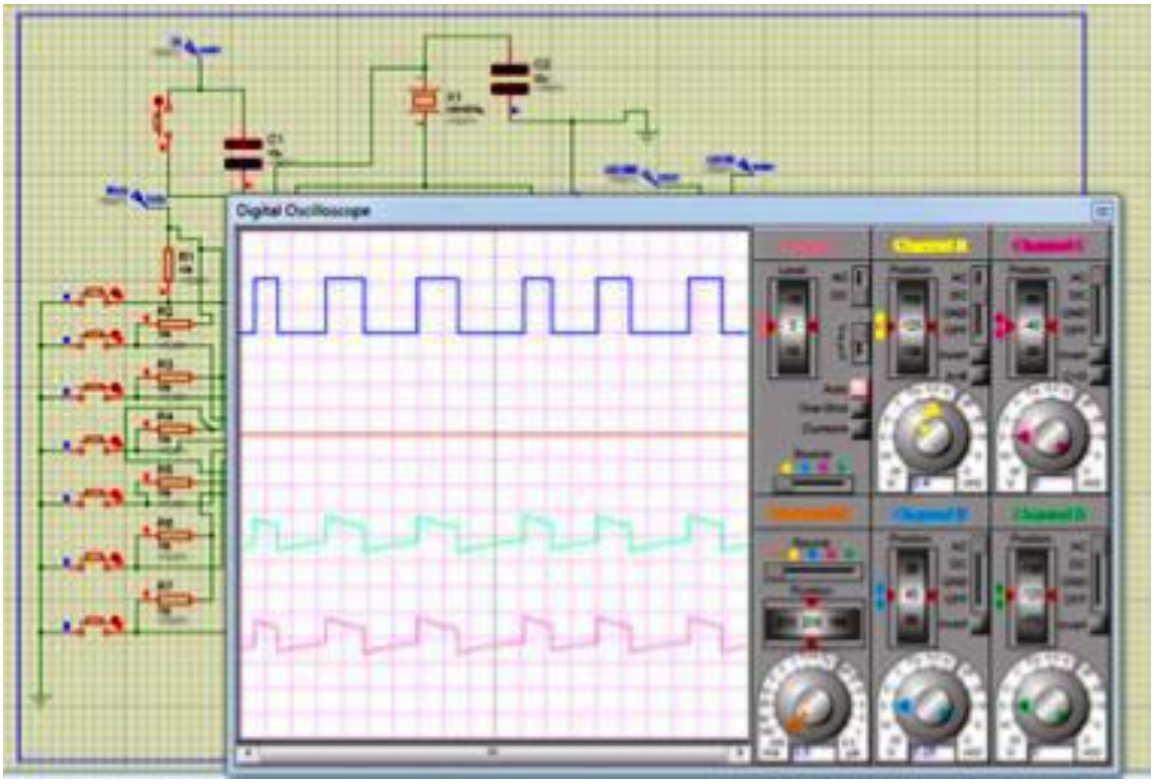


Fig.9: (B). Waveform of Anti-Clockwise Movement of Dc Motor

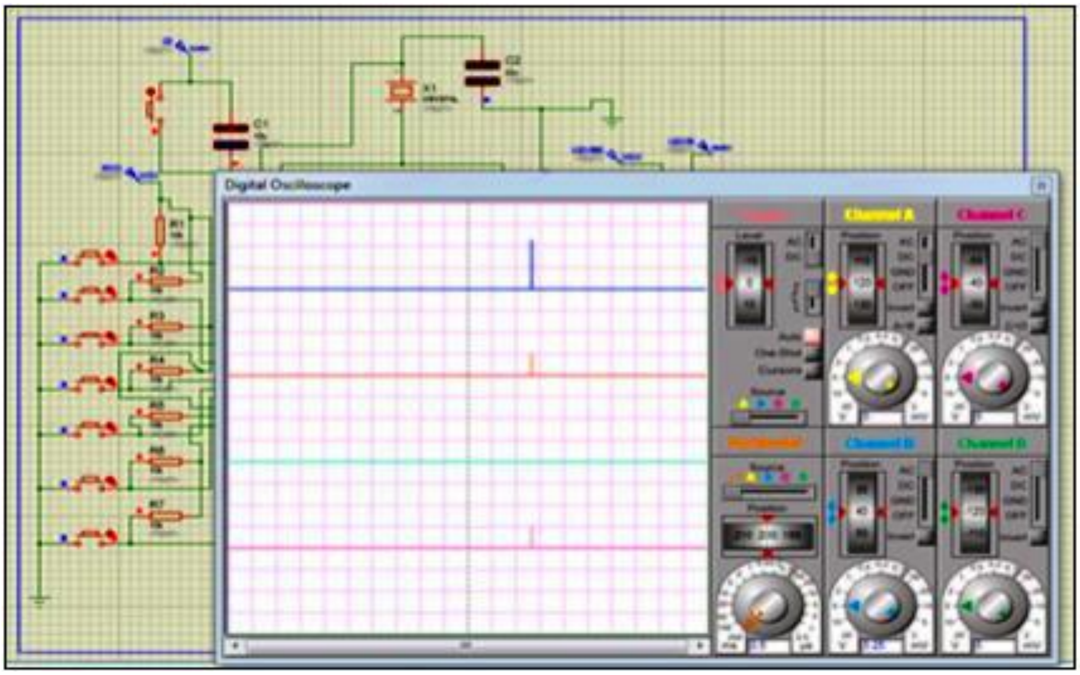


Fig.9: (C). Waveform of Forward Braking of Dc Motor

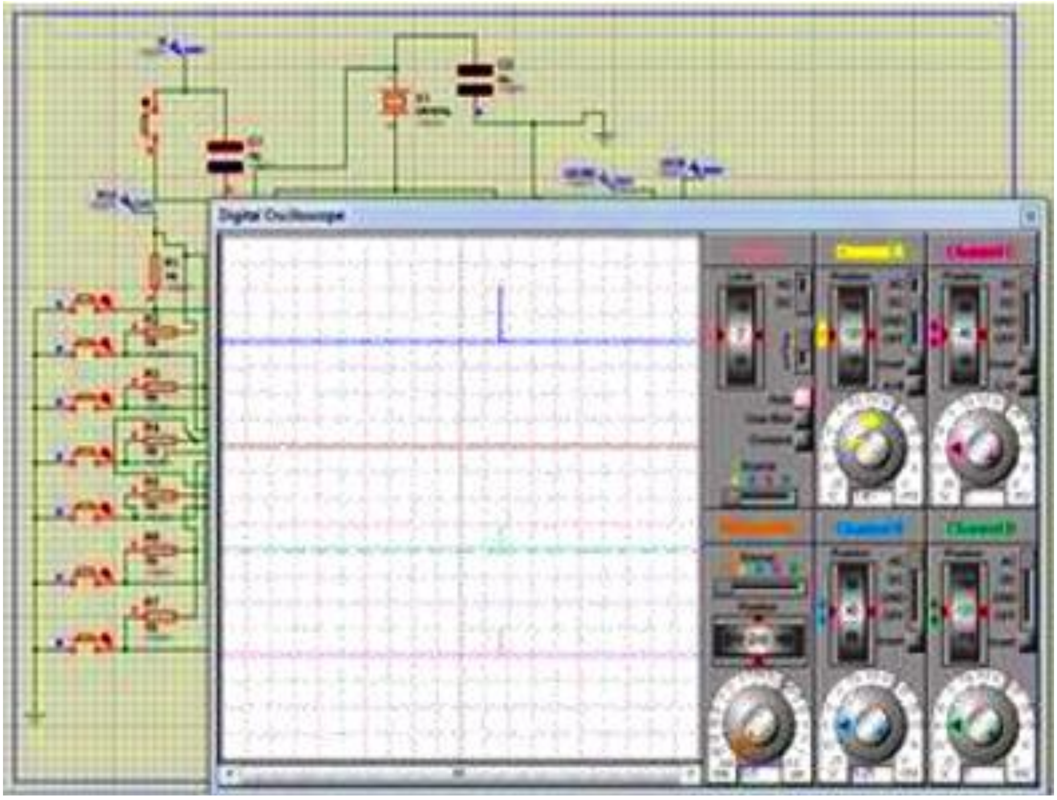


Fig.9: (D). Waveform of Reverse Braking of Dc Motor

ii. 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

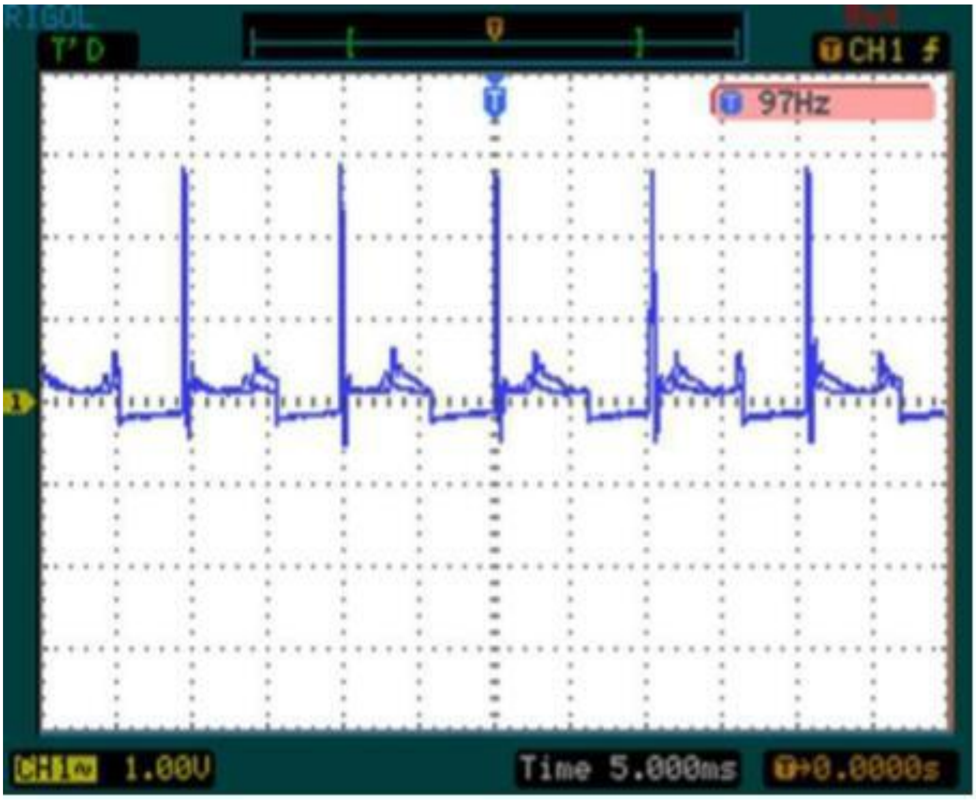
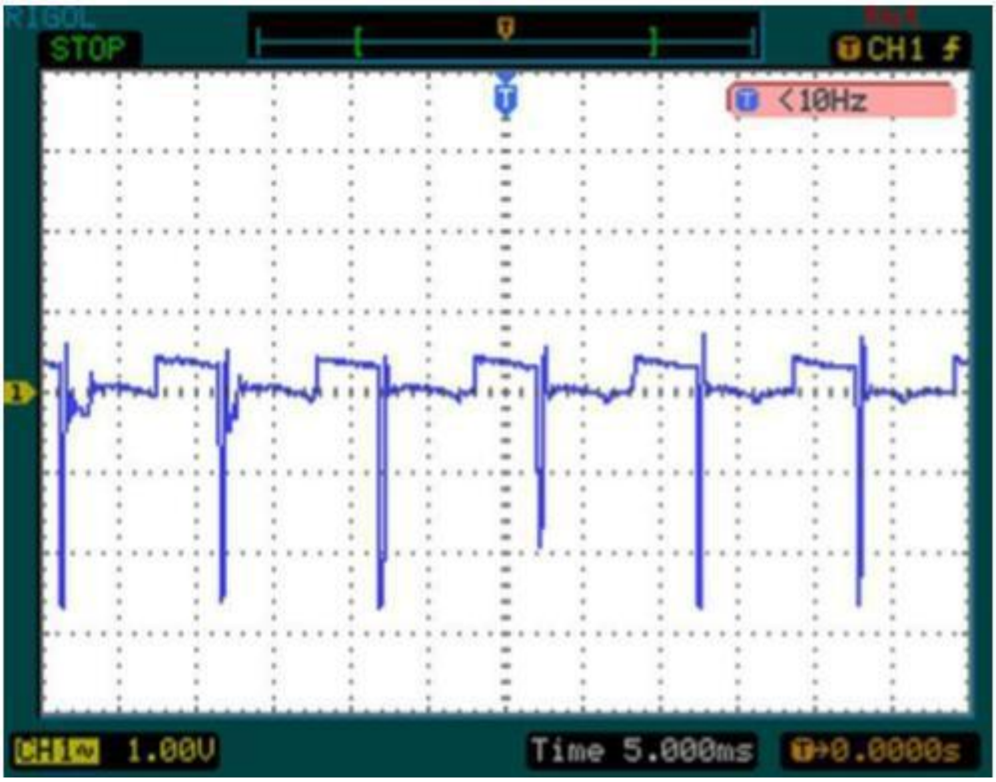


Fig.9: (E). Clockwise Movement of DC Motor



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

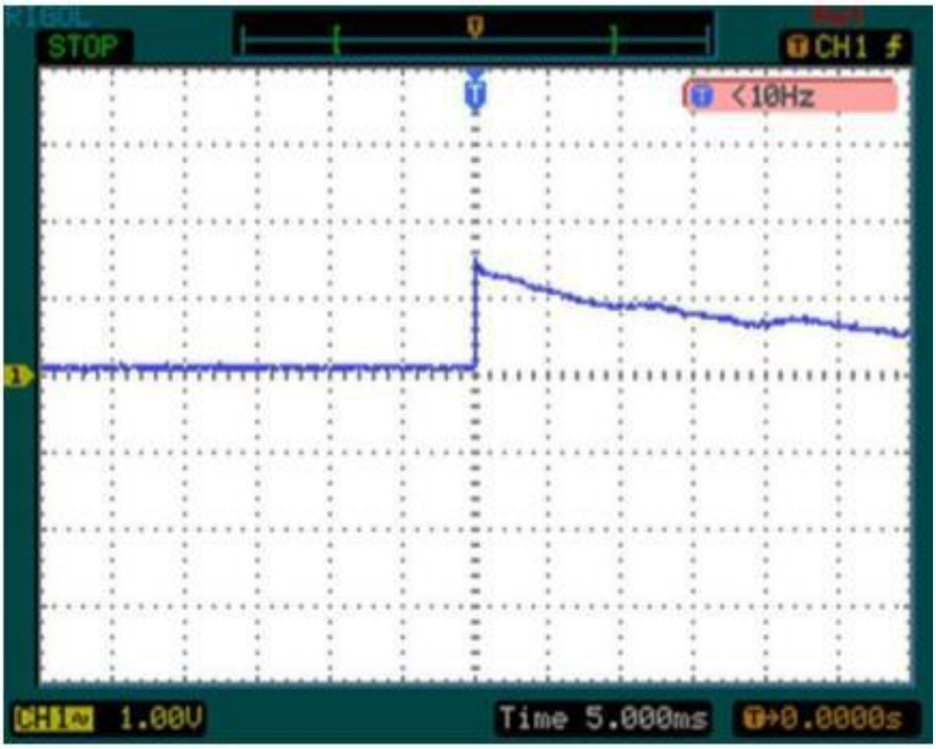


Fig.9: (G). Waveform of Forward Braking

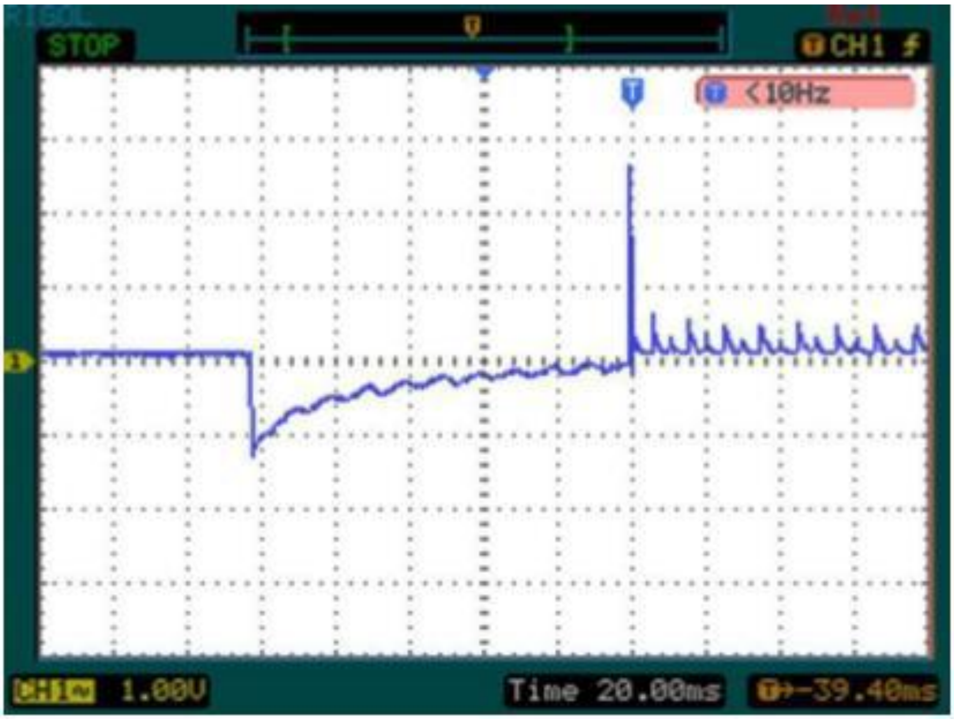


Fig.9: (H). Waveform of Reverse Braking

VI. CONCLUSION

The four quadrant DC motor speed control hardware is designed using microcontroller. Designed for the four quadrant DC motor speed control using microcontroller, is the prototype hardware model. 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 method was used to control the speed of the DC motor. Therefore, through difference in the duty cycle, the voltage applied varies and the speed of the 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 one 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 the 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 occurring. It is due to different nonlinear electronic components such as diodes, transistors etc. present in the prototype developed model. It is proved to be operated so simply. This project is realistic and highly economically feasible, and has the benefit of operating motors with higher ratings. It is good in terms of reliability and durability and also gives a precise and efficient way to monitor speed 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 efficiently in all four quadrants. They also achieve regenerative braking. Simulation and experimental results work together and effectively support the method created.

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