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Microcontroller Based DC Motor Speed Control Using PWM Technique

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ABSTRACT
This paper reports a microcontroller based control system to change the speed and direction of rotation of DC motor. Armature voltage is varied by pulse width modulation (PWM) of input DC voltage by using the developed microcontroller's program. Thus the speed of the DC motor is changed. Direction of rotation of DC motor is changed by initiating an interrupt signal to the microcontroller using push switches. To drive the DC motor, a four channel monolithic integrated buffer circuit was used. PCB of the control circuit has also been designed and fabricated. Test data shows very good agreement with the expected results.

KEY WORDS: Microcontroller, DC motor speed, PWM signal.

1. INTRODUCTION

DC motors are being used in many control systems now a days [1-3]. For the fractional horsepower and variable speed drive systems, DC motor is a good choice. Because, torque of DC motor is also quite high and its speed regulation is very low. Development of rare earth magnet advances in brush commutator technology and advanced manufacturing techniques of the Permanent Magnet (PM) dc motor with ironized rotor and rotor with very low inertia extends its use in several types of control system [4].

With the development of technology, microcontroller is becoming more suitable chip to control various electro-mechanical devices [5-6]. Microcontrollers are used in automatically controlled products and devices. By reducing the size and cost, microcontrollers make it economical to digitally control even more devices and processes [7].

To obtain variable speed of DC motor, usually armature voltage and field currents are varied. But the range of speed variation is good if armature voltage can be varied. To get variable DC voltage chopper or PWM circuit can be used. PWM is routinely used to control the speed of DC motors. But designing and implementing the chopper or PWM circuit is very cumbersome [8-10].

This paper reports a microcontroller based control system to change the speed and direction of rotation of DC motor. Armature voltage is varied by pulse width modulation (PWM) of DC input voltage by using the microcontroller that sends the signals at the microcontroller's PWM terminal. Thus the speed of the DC motor is changed. Direction of rotation of DC motor is changed by switching the signals at armature terminals of the DC motor by initiating an interrupt signal to the microcontroller. Hardware implementation was done using an 8 bit ATmega16 microcontroller and its software was written in C language using the AVR Butterfly that makes the hex file to be sent to the microcontroller by the Ponyprog software through the ISP port (DB 25) [11]. Since its output current is very low, a four channel monolithic integrated buffer circuit (L293) was used. This IC is capable of handling high voltage and high current and of driving the inductive loads. A separate DC power supply unit was also designed for the various ICs of the system. PCB of the control circuit has also been designed using Proteus software and then the PCB was fabricated. Finally, the designed circuit was tested by controlling the DC motor and results are recorded for various speeds. Measured data show very good agreement with the expected output.

2. HARDWARE SYSTEM DESIGN

The block diagram of the microcontroller based display system is shown in Fig. 1. It has four units, such as, a control unit, a driver unit, a DC power supply unit and a switching unit. The control unit part consists of an 8 bit ATmega16 microcontroller [12]. Its function is to get input signals from the different switches of the switching unit (SW0, SW1 and SW2) through its interrupt inputs (PB0, PB1 and PB2) respectively and then to send the appropriate output ports (PC0, PC1 and PD5). Ports PB0 and PB1 are used to increase and decrease the duty cycle of the output DC signals respectively while port PB2 is used to change the direction of rotation. Ports PC0 and PC1 are used to send the signals for the two terminals of the DC motor depending on the signal at port PD5. Port PD5 is connected to the driver IC's

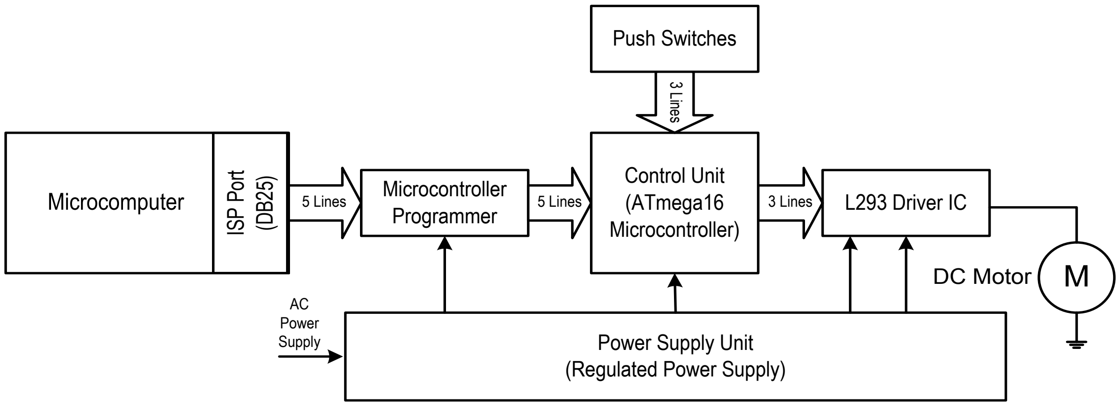

Fig. 1 Block Diagram of the DC Motor's Speed Control System

EN input. When SW0 or SW1 are pressed then microcontroller sends an appropriate signal to the port PD5 so that the duty cycle of the chopped output at the ports PC0 or PC1 can be increased or decreased respectively. DC motor's rated voltage, current, power and speed are 200 V, 1.5 A, 300 W and 1500 rpm respectively.

For the driver unit, a push-pull type four channel driver IC (L293) was used [13]. This is a monolithic integrated high voltage, high current driver designed to accept standard DTL or TTL logic levels and drive inductive loads (such as, relays, solenoids, DC and stepping motors) and switching power transistors. To simplify use as two bridges each pair of channels is equipped with an enable input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included. This device is suitable for use in switching applications at frequencies up to 5 kHz. Each of its output channels has the current capability up to 600 mA. It has enable (EN) facility.

The power supply unit is designed by using a step down transformer, bridge rectifier, capacitors and regulated power supply ICs of 7805 and 7812 to get the DC voltages of 5 V and 12 V respectively [14].

The switching unit has three push type switches (SW0, SW1 and SW2) to send inputs or interrupts to the microcontroller's PB0, PB1 and PB2 ports respectively.

The complete circuit diagram drawn using Proteus software is shown in Fig. 2. Finally, the PCB was designed using Proteus software and implemented on the copper board but it is not shown here for brevity.

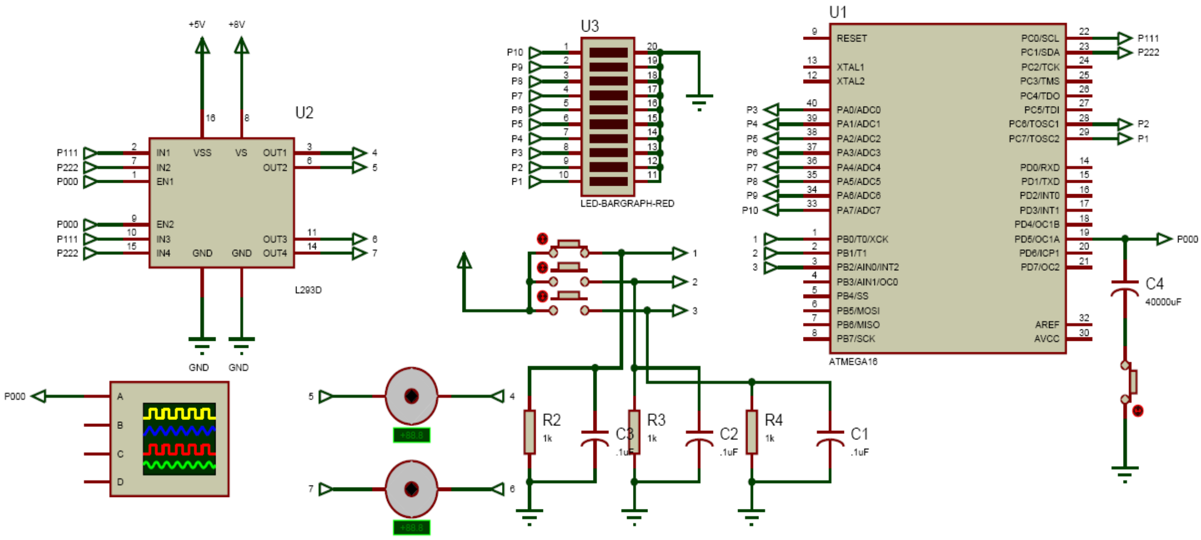

Fig. 2 Circuit Diagram of the contol system

3. SOFTWARE DEVELOPMENT

The program is developed for the microcontroller using the WinAVR Butterfly software [15] in C language, then debugged and edited as required and finally the hex codes are generated using a microcomputer. The hex codes of the developed program are sent to the microcontroller through the parallel port (DB25) of the microcomputer by the Ponyprog software. Parallel port was connected to the miso, mosi, ack, reset and gnd terminals of ATmega16 microcontroller. The ISP Programmer was also developed specially for this work to download the hex codes to the microcontroller.

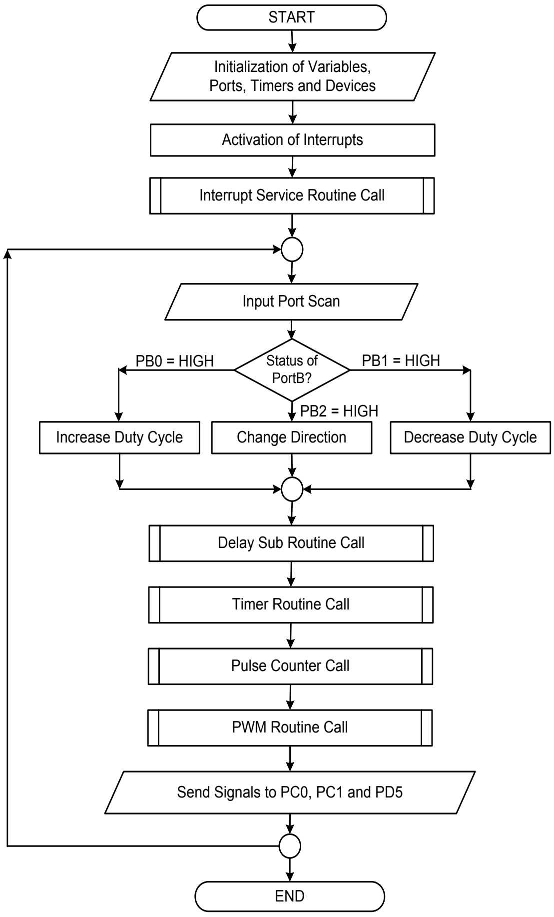

Fig. 3 Flow chart of the program

C is a general-purpose programming language that can work on any microprocessor that has a C compiler written for it. C abstracts the concepts of what a computer does and provides a text based logical and readable way to get computers to do what computers do. WinAVR is a set of tools for C programming. The AVR microcontroller family is a suite of executable, open source software development tools for the ATMEL AVR series of RISC microprocessors hosted on the Windows platform. Ponyprog works as burner software for the microcontroller.

In this work, we need to develop and use interrupt service routine, delay sub-routine and PWM function to make change the DC voltage of the armature and hence the speed of the DC motor and also to change the direction of rotation. The main programs have been developed to calculate the appropriate number of pulses and amount of time required for the pulses. The flow chart of the program is shown in Fig. 3.

4. RESULTS

The whole system is implemented in the laboratory in bread boards and the photograph of the whole system with DC motor is shown in Fig. 4. The armature voltage is measured using voltmeter and speed of the motor is measured using optical digital tachometer. The recorded results are shown in Table 1. When armature voltage is varied the field coil is separately excited with a constant voltage of 200 V. The measured field current is 476 mA. It has been observed that as the armature voltage increases due to the increment of the duty cycle speed of the DC motor also increases.

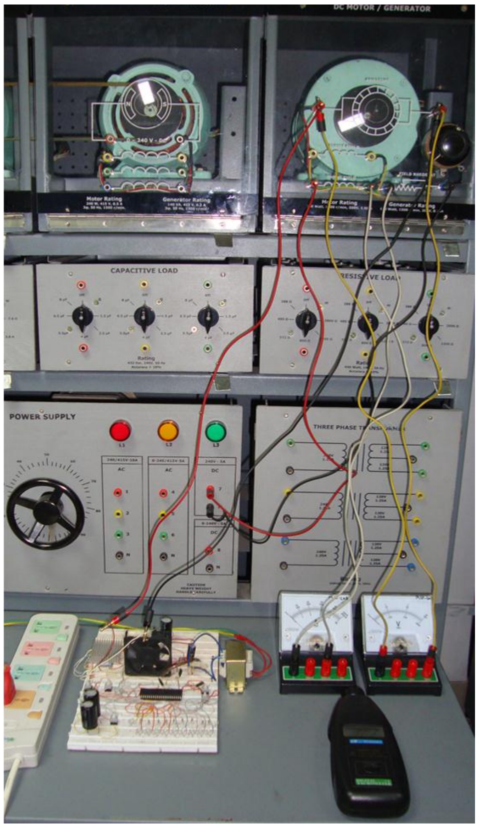

Fig. 4 Photograph of the DC motor control system

Table 1 Observed armature voltage and shaft speed

No of observations	Armature Voltage (Volt)	Shaft Speed (rpm)
1	10	77
2	18	138

3	24	193
4	33	265
5	41	325
6	48	380
7	56	450
8	61	483
9	70	569
10	86	693
11	98	785
12	114	920
13	122	998
14	143	1156
15	174	1425

5. CONCLUSIONS

In this work, a microcontroller based DC motor control system design is described to change the speed and direction of rotation of DC motor. Armature voltage is varied by pulse width modulation (PWM) of input DC voltage. Direction of rotation of DC motor is changed by initiating an interrupt signal to the microcontroller. To drive the DC motor, a four channel monolithic integrated driver circuit with diode clamps was used. PCB of the control circuit was been designed and the whole system is implemented on it. Test results are presented in tabular form and it shows very good agreement with the expected output.

6. FUTURE WORKS

Field flux can be controlled to vary the speed of the DC motor using the same circuit. In that case driver circuit may be required. Feedback may be incorporated in the system to make it close loop control system. Protection from the maximum input voltage, maximum speed of DC motor etc. may be incorporated in the software.

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