Chopper based Speed Control of DC Motor using ATMEGA16 Microcontroller

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Abstract— The speed control of DC motor for various applications is very important because DC motors have been widely used in many industrial applications such as electric vehicles, steel rolling mills, electric cranes, and robotic manipulators due to precise, wide, simple, and continuous control characteristics. There are various methods of speed control of DC drives – armature voltage control, field flux control and armature resistance control. However, the conventional methods have some demerit because some power is wasted in control resistance. This paper deals with controlling DC motor speed through combination the Chopper circuit and ATMEGA16 microcontroller. In this work, PWM that can be used for speed control of a DC motor is generated using ATMEGA16 microcontroller. DC motor is driven by a driver IC IR2100. The H-bridge MOSFET Chopper is driven by a driver IC IR2100 through PWM signal generated by the microcontroller. This work is a practical one and high feasible according to economic point of view and accuracy and it has been tested on 0.5HP DC motor.

Key words: PWM, DC Motor, Microcontroller, ATMEGA16, Speed Control, Four Quadrant Chopper

I. INTRODUCTION

An electrical drive consists of electric motors, power controller and energy transmitting shaft. In modern electric drive system power electronic converters are used as power controller. Electric drives are mainly of two types: DC drives and AC drives. They differ from each other in this way that the power supply in DC drives is provided by DC motor and power supply in AC drives is provided by AC motor. DC drives are widely used in applications requiring adjustable speed control, frequent starting, and good speed regulation, braking and reversing. Some important applications are paper mills, rolling mills, mine winders, hoists, printing presses, machine tools, traction, textile mills, excavators and cranes. For industrial applications development of high performance motor drives are very essential. DC drives are less costly and less complex than AC drives. There are various methods of speed control of DC drives – armature voltage control, field flux control and armature resistance control. However, the conventional methods have some demerit because some power is wasted in control resistance. Presently advancements in power electronics made motor drive as one of the crucial components for industrial benefits. The motor drive must have superior dynamic stability and steady state response. DC motors provide reliable speed control environment for acceleration and deceleration. So In recent years, Advancements in semiconductor integration and fabrication techniques have made compact, faster microprocessors and microcontrollers available at reduced cost and Four Quadrant chopper operates DC motor are extremely used in adjustable speed drive and position control application. The proposed converter utilizes combination of PWM and ATMEGA16 microcontroller for speed control of dc motor on either direction. The smooth control, high efficiency, faster response and regeneration facility can be obtained using this technique.

II. PROPOSED SCHEME

The block diagram of proposed scheme is shown in Fig 1.

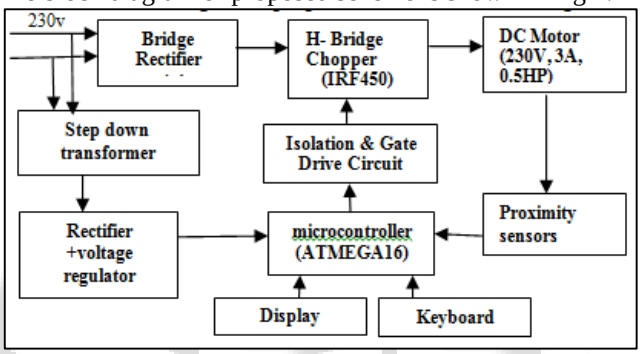

Fig. 1: Block Diagram of Proposed Scheme

A. Bridge Rectifier with Filter

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid state switches. Depending on the load current requirements, a proper bridge rectifier is selected. Components' ratings and specifications, breakdown voltage, temperature ranges, transient current rating, forward current rating, mounting requirements and other considerations are taken into account while selecting a rectifier power supply for an appropriate electronic circuit's application. Bridge rectifier converts the sinusoidal signal into unidirectional signals. The bridge rectifier consists of four diodes, two in series and two series in parallel as shown in fig2.

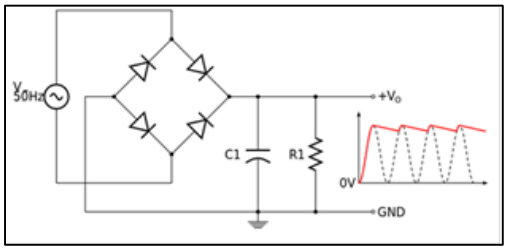

Fig. 2: Circuit diagram of bridge rectifier with Filter

The rectifier gives full wave rectification and the filter connected to the output is removes the voltage ripples, hence converting pulsating dc into a pure direct current.

In the proposed work 6A100 diodes are used and a capacitor filter is used.

B. H-Bridge MOSFET Chopper

Chopper is device which converts unregulated DC into regulated DC. In this work we used a four quadrant chopper to control DC motor as shown in figure 3.

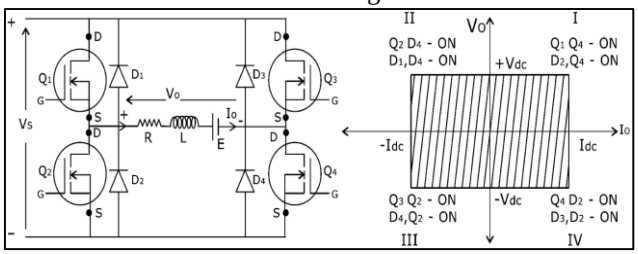

Fig. 3: Circuit diagram of H-Bridge MOSFET Chopper

A four quadrant chopper with MOSFET switches. Each MOSFET has a freewheeling diode across it and a snubber circuit to limit the rate of rise of the voltage, the dc bus is composed by a dc source and a capacitor connected across it to maintain a constant voltage. The converter is controlled in such a way that the MOSFETs in the same arm do not conduct simultaneously. In the proposed work IRF450 MOSFET is used for H-Bridge MOSFET Chopper.

C. Isolation & Drive Circuit

The isolation and drive circuit is used to provide required gate voltage and current to MOSFET's for switching. It provides electrical isolation between power switch and control circuit. Drive circuit amplifies control signals to level required to drive power switch. In the bridge chopper there are four MOSFET's, so separate isolator and driver circuits are used to drive each MOSFET.

The dc supply required for driver circuit is derived from the DC regulated power supply section (LM7812). The supply is given to the opto coupler (PC817). The control circuit generates the required gate pulses. The opto coupler is used for isolation. The opto coupler consists of a Light Emitting Diode (LED) and a photo transistor. When the signal is applied to the LED, it turns on. Its light falls on photo transistor. Therefore it starts conducting. There is no electrical connection between LED and photo transistor. The MOSFET driver used in the proposed work is IR2110.

D. Micro Controller

A micro controller is a small computer on a single IC containing a processor core, memory, and programmable input output peripherals. These are used in automatically controlled products and devices, such as automobile engine control systems, toys, printers, remote controls etc. This sends a signal to isolation & drive circuit to operate MOSFET's In the proposed work ATMEGA16 microcontroller is used. The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

The ATMEGA16 provides the following standard features: Advanced RISC Architecture, 131 Powerful Instructions – Most Single-clock Cycle Execution, 32 x 8 General Purpose Working Registers, Fully Static Operation, Up to 16 MIPS Throughput at 16 MHz, On-chip 2-cycle Multiplier, High Endurance Non-volatile Memory segments, 16K Bytes of In-System Self-programmable Flash program memory, 512 Bytes EEPROM, 1K Byte Internal SRAM, Write/Erase Cycles: 10,000 Flash/100,000 EEPROM, Data retention: 20 years at 85°C/100 years at 25°C(1), Optional Boot Code Section with Independent Lock Bits, In-System Programming by On-chip Boot Program, True Read-While-Write Operation, Programming Lock for Software Security.

E. Proximity Sensors

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Some know this process as "thermo sensation". Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object. In the proposed work inductive proximity sensor is used.

F. Frequency to Voltage Converter

A frequency to voltage converter is composed of a differentiator, two RMS-DC converters, a divider and voltage to current converter. The output signal is linearly proportional to the input frequency, ωin, and insensitive to the input signal amplitude, A.

G. Direct Current Motor

DC motor is similar to DC generator; in fact the same machine can act as motor or generator. The only difference is that in a generator the EMF is greater than terminal voltage, whereas in motor the generated voltage EMF is less than terminal voltage. Thus the power flow is reversed, that is the motor converts electrical energy into mechanical energy. That is the reverse process of generator.

DC motors are highly versatile machines. For example, dc motors are better suited for many processes that demand a high degree of flexibility in the control of speed and torque. The dc motor can provided high starting torque as well as high decelerating torque for application requiring quick stop or reversals. DC motors consist of one set of coils, called armature winding, inside another set of coils or a set of permanent magnets, called the stator. Applying a voltage to the coils produces a torque in the armature, resulting in motion.

Direct current (DC) motors have been widely used in many industrial applications such as electric vehicles, steel rolling mills, electric cranes, and robotic manipulators due to precise, wide, simple, and continuous control characteristics.

DC motors are suited for speed control with over wide range and control is easily to achieve compared with others.

III. HARDWARE SETUP

The speed control of DC Motor is based on four quadrant chopper using PWM technique and ATMEGA16 Microcontroller is implemented in this work. In order to control the DC Motor an ATMEGA16 microcontroller is used. ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture.

Fig 4 shows the hardware setup of the proposed project.

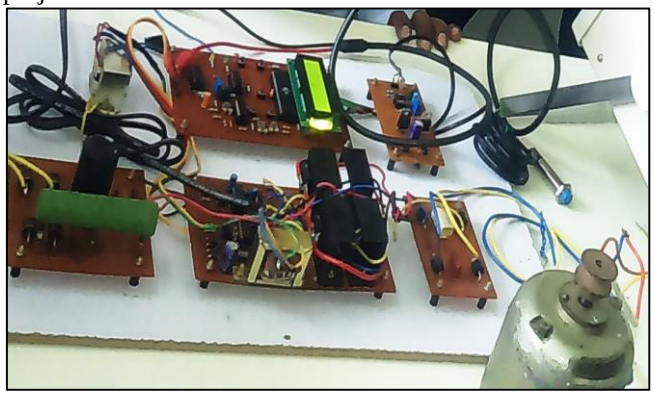

Fig. 4: Photograph of proposed Hardware Setup

IV. EXPERIMENTAL RESULTS

The proposed project is tested on 220V, .5HP, 9000 RPM DC motor. H-bridge gate drive chopper pulses are shown in fig 5.

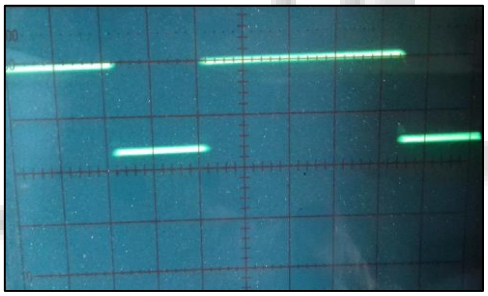

Fig. 5: H-Bridge gate drive pulses

Measured parameters of DC Motor listed in table 1.

Input Voltage= 120 V	
Duty Cycle (%)	RPM
20	2400
30	2700
40	3100
50	3900
60	4100
70	4350
80	4950

Table 1: Parameters of DC Motor

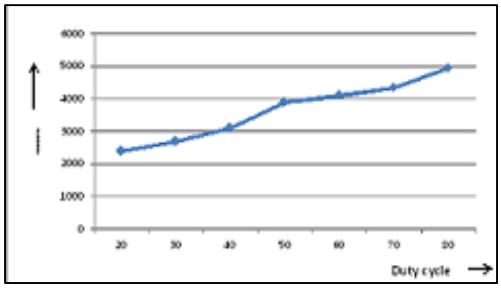

Fig. 6: speed versus duty cycle curve

Measured parameters of DC Motor listed in table 2.

Input Voltage= 170 V	
Duty Cycle (%)	RPM
20	3800
30	4100
40	4700
50	5160
60	5800
70	6100
80	7500

Table 2: Parameters of DC Motor

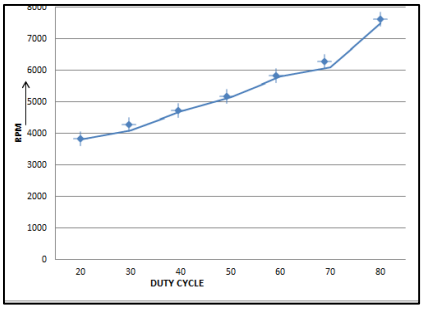

Fig. 7: Speed versus duty cycle curve

Measured parameters of DC Motor listed in table 3.

Input Voltage= 220 V	
Duty Cycle (%)	RPM
20	3950
30	4305
40	4980
50	5600
60	6210
70	7950
80	8750

Table 3: Parameters of DC Motor

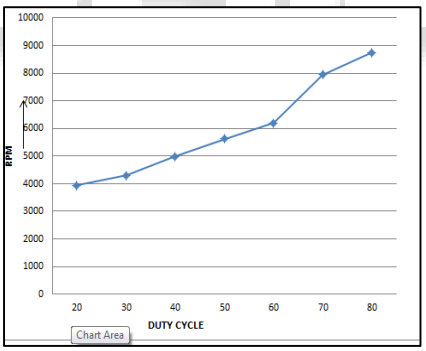

Fig. 8: Speed versus duty cycle curve

V. CONCLUSION

This work is intended to demonstrate the successful application of chopper based speed control of DC motor using PWM technique and ATMEGA16 Microcontroller. It controls the speed of a motor by giving instructions to the microcontroller to reduce the hardware control circuitry. Direction and rotation speed of a DC motor can be controlled with PWM method using proximity sensor.

This work is successfully tested on 0.5 hp, 3A, 9000 rpm DC motor using chopper circuit having MOSFET switches in all four quadrants of DC motor i.e. forward braking, reverse motoring and reverse braking. The system can deliver maximum torque in the entire speed range from 2400 rpm to 9000 rpm. Compared to conventional systems the proposed work offers improved performance and this

work is a practical one and high feasible according to economic point of view and accuracy.

In future, system can be modified by introducing PID control we can achieve better response. It is also possible to design fuzzy PID control of DC motor by using fuzzy rules in this concept.

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