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A Novel Low Cost RCD Snubber and Totem Pole Drive Circuit for PMDC Motor

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Abstract:-- **Manufacturing plant in industries like chemical, pharmaceutical, plastic and textiles all need speed variation. And it could be flat belt application, flow management application or combining of liquids. There are different kinds of motors-AC, PMDC, Servo or steppers which are used according to the applications. Of these, PMDC motors have widely used .The PMDC motors are easy to control compare to other types of motors. The treadmill is a walker which is used for exercise. This is one application in which a PMDC motor plays an important role in its operation. The PMDC motors are used to operate these machines.**

In this paper, implementation of PIC 16F877A microcontroller to change the speed of PMDC motor fed by a MOSFET has been investigated .The MOSFET is driven by high frequency PWM signal .Controlling the PWM duty cycle is same as to control the motor terminal voltage, that changes directly the motor speed. Experimental results are obtained that shows the use of microcontroller for speed management and over current protection of a DC motor.

Index Terms— **MOSFET, PWM, PMDC motor, PIC microcontroller, Treadmill etc.**

I. INTRODUCTION

The power electronics makes not only a good control of electrical machines caused by precise control and quick response, but also makes easy implementation with low maintenance cost. In parallel with the advance in power electronic there is a fast growth in microcontroller primarily based control systems due to the microcontroller flexibility and versatility. This can be due to use of control algorithms which is implemented within the software [1].

Adjustable speed drives could also be operated over a large range by changing armature or field excitation. Speeds less than the rated value by armature voltage control and more that the rated value rated by field excitation variation, the growth of different solid state switching devices in form of diodes, semiconductor devices in the form of diodes, transistors and thyristor together with different analog/digital chips employed in firing/cont rolling circuits, have made DC drives easily accessible for control in number of areas of applications[2].

Speed management of a low power drives by applying low voltage is simple. These types of drives are difficult to use for applications wherever high torque is needed. The designing of a high capacity variable speed drives is more complex due to thermal run away of switching devices like power MOSFET, if used in switching applications . The snubber circuit protects MOSFET from extreme temperature loss. The frequency of switching devices when goes on increasing, the rate of change of voltage (dv/dt) & rate of change of current (di/dt) takes place across the MOSFET terminals. This makes the thermal breakdown of power MOSFET. The Laszlo Balogh [6] has shown systematically, the design of high performance gate drive circuits for switching applications with high speed. Paper consists of an introduction of MOSFET technology and switching operation, design procedure for ground reference and high speed gate drive circuits in detail.

The controlling of a gate charge of a MOSFET during turn off protects the MOSFET from ringing & overshoot caused by dv/dt. John E.Makaran [3] has given the relation between VGS &VDS to obtain the two stage control of gate charge removal at the time of turning off MOSFET.PMDC motor offers the simplest way for speed regulation using PI controller, as compared to other controllers, literature [4] shows the response of PI, PD &PID controller once it's connected to PMDC drive. Fuzzy controller with PIC 16F877A may be used for speed control of any motor solely by changing control algorithm & by changing program while not changing hardware [5].Design of driver circuit is needed for switching of a high power motor which gives a smooth control of motor speed [7].The objective this paper is to suggest a microcontroller based closed loop controller. The interfacings of a circuit with software are all designed

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with a temperature control system to protect the motor from overheating.

II. HARDWARE DESIGN

The hardware system consists of DC shunt motor, power control circuit, MOSFET driver circuit, PIC microcontroller 16F877A, speed sensor circuit, and temperature control circuit.16F877A microcontroller gives control algorithm by conditioning the speed, current signals and controls the speed according to reference input given through the keypad. The software includes a routine to read the motor temperature and this shutdown signal it sends to DC motor to protect the system from overheating.

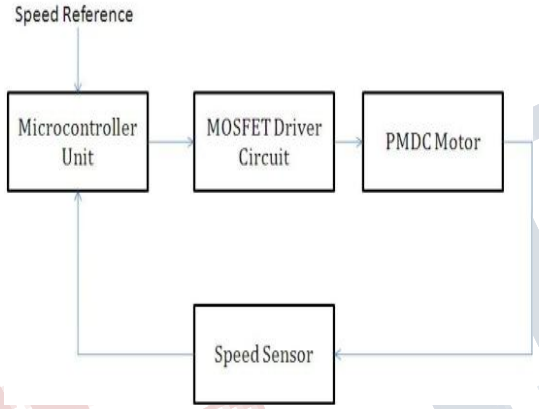

Fig.1 Block Diagram

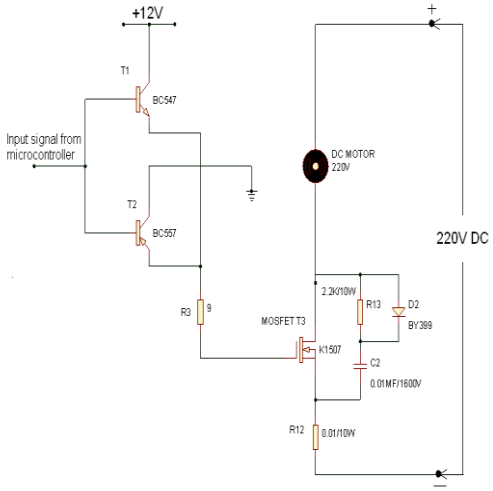

Fig.2 Circuit Outline

III. DESIGN OF SNUBBER CIRCUIT

When a DC motor is suddenly turned OFF, the back EMF in the motor inductance is dissipated in the switching device which causes an overvoltage across the device. The magnitude of this back EMF is proportional to the amount of inductance and rate of turn off current. This situation becomes very dangerous at the time of fast switching of MOSFET devices. These devices become turn OFF and turn ON at high magnitude of currents in short duration of time which rises potentially destructive voltage transients. Thus the di/dt generated in the MOSFET could be of few thousand A/us. Proper attention need to be provided to protect these devices form destruction. It is found that snubber offers good protection against voltage transients during turning on and turning off devices. The use of such type of protection circuits allows quick and safe operation by operating the device within the boundaries of rated safe operating area.

IV. RCD SNUBBER CIRCUIT

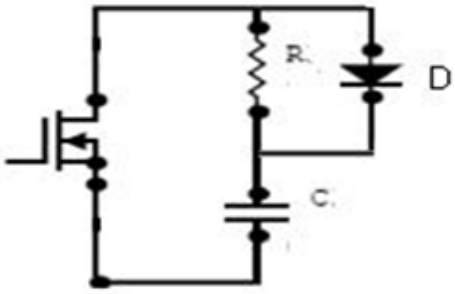

Fig.3 Snubber Circuit

The charge discharge snubber as shown in above figure can be used to minimize turn off dissipation in MOSFET.During MOSFET turn on the snubber capacitor is fully discharged and during turn off it is fully charged. This circuit reduces the rate of rise of voltage across MOSFET at turn off and gives softer switching and thereby reducing the losses in MOSFET.

V. SPEED MONITERING SYSTEM

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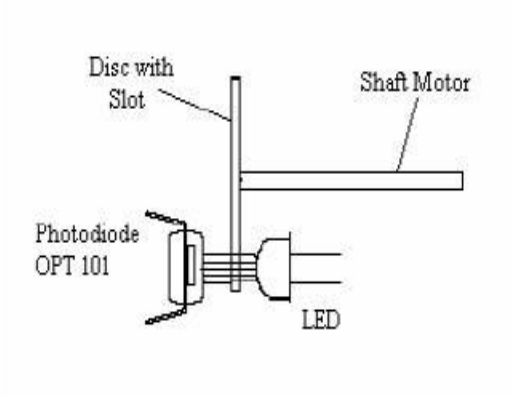

Fig.4 Speed monitoring system

The speed monitoring system consists of an optical encoder as a speed sensor to measure the speed of motor. This sensor is used as a velocity sensor is capable of much better performance than the generator type of tachometer (used as a back emf).This system consists of a optical disc which is properly mounted on the motor shaft, which generates a frequency directly proportional to motor speed. The output of tachometer doesn't get change due to change in gap, temperature and magnet strength. The analog tachometer gets directly affected by all the problems listed above. The encoders available in the market are very expensive. In this system an optical encoder is prepared to reduce the cost of system. Fig. Below shows the schematic of the optical encoder in action respectively. The speed accuracy over fractions of a revolution depends on the quality of the optical encoder. An optical disc made by card board is mounted on the shaft of motor .This disc has N radial lines on its surface. A single slot is made in the disc to pass the LED lights from one side to another side. A LED is put on one side of disc as transmitter and a photo diode on other side as a receiver to sense the speed of motor.

VI. TEMPERATURE CONTROL SYSTEM

The motor winding temperature gets increases due to continuous operation of treadmill. The motor conductors gets short circuited due to increased temperature. Hence there will be chances of burning of motors is possible. In this system motor temperature protection is provided. The temperature sensor IC LM 35 is used to sense the motor temperature. This sensor is fixed near to motor winding. When temperature of motor increases above the set value, signal is transferred from sensor to relay circuit, which stops the motor immediately. Hence the motor is protected from burning.

VII. SOFTWARE DESIGN

The microcontroller is a brain of the DC motor speed control system. In this system microcontroller chip PIC16F877A is selected for the purpose of controlling the speed of DC motor manufactured by Microchip. The selection of chip is based on several reasons:

a. The size of chip is small and equipped with sufficient output ports .No need to use a decoder or multiplexer.

b. It has very low current consumption

c. The pulse width modulation techniques (PWM) are inside the chip itself which allow us to vary the duty cycle of DC motor drive.

d. The controller chip is a very simple to understand and powerful. Users would only need to learn 35 single word instructions in order to program the chip.

e. It is programmed and reprogrammed easily (up to 10,000,000 cycles) by using the universal programmer in robotics

In this system microcontroller receives the desired speed from user through thumbwheel switch. The actual speed will be compared with the desired speed and the correction signal is given to microcontroller to maintain the DC motor speed at the desired speed.

VIII. SPEED CONTROL PROGRAM FLOW

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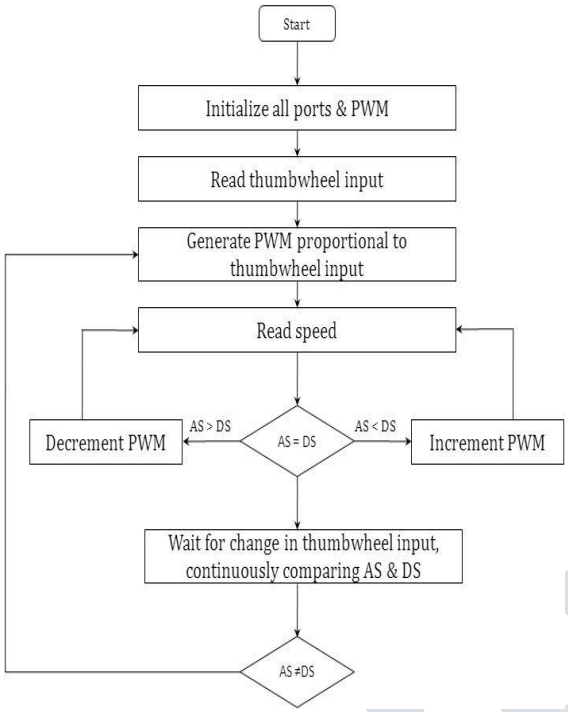

Fig 5 Speed Control Program Flow Chart

IX. CONCLUSION

The above PID speed control implementation through PIC 16F877A microcontroller for a Permanent magnet DC motor for treadmill reduces the voltage fluctuations. A low cost RCD snubber and Totem pole driver circuit has very low effect of dv/dt-change in voltage and di/dt- change in current. The response time of motor gets improves by PID control strategies.

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