

SPEED CONTROL OF SEPARATELY EXCITED DC MOTOR USING CHOPPER

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ABSTRACT

Now a days in industry DC motor is widely used for its easy speed control and load characteristics, as it is effective and provides precise output so application of DC motor is large for commercial purpose. Speed control of DC motor is very crucial in application where large variation of speed is required, so we used chopper using IGBT to control the speed of separately excited DC motor. Chopper based speed control system consists of electronic components which include IC 555 timer for generating PWM, IGBT switch based chopper, 4007 diode, electrolytic and 104 capacitor is used in 12 volt rectifier, opto-coupler is used for electrical isolation. This paper shows the control of 1KW, 4A DC motors efficiently without using costly components and complicated circuit.

KEYWORDS: DC motor, chopper, Pulse Width Modulation, 555 Timer

I. INTRODUCTION

Speed controllers of DC motor are very useful for controlling and automation systems in industry. In this paper we use IGBT based chopper circuit for speed control and IC 555 timer to generate the PWM to trigger gate of IGBT, IC 555 is used to control the PWM frequency. When the voltage of the supply connected to motor is high then the speed is more and when the voltage amplitude is low the speed is low, and this voltage amplitude is controlled through triggering of chopper circuit. As soon as gate pulse is provided it is on and in the absence of gate pulse no voltage output is obtained from chopper circuit. In this way by changing PWM characteristics we can control chopper output voltage. In this paper we used PWM method so it switches the motor 'on' and 'off' with a pulse wave. The main objective of this paper is the easy implementation of hardware of electronic circuitry based speed control of DC motor. For the required speed the speed controller takes signal represent and to drive a motor at required speed.

The organization of this paper has been done in the following manner. In the first section introduction is given. In the second section we mentioned about theory about the topic, in the third section we discussed about design methodology. In the fourth section we mentioned about the result and discussion made after the successful implementation of design. In the last section conclusion of the paper is given.

II. THEORY

A. Controlling through chopper

Armature voltage control method is used to control the speed of separately excited dc motor and this armature voltage can be controlled through various ways but we choose chopper circuit for voltage regulation. In this project we use IGBT based step down chopper its mean voltage can be vary below rated value, to trigger the gate signal PWM signal is required. Though there are various circuit by which PWM signal can be generated like by using microcontroller or through fuzzy logic but here in

this project we use IC 555 timer circuit for generation of pulse train. Output voltage can be obtained on chopper circuit when gate signal is on and when gate signal is off there is no output voltage. So we can easily understand output voltage can be easily regulated by turning on and turning off of gate signal. 555 PWM circuit are shown in figure- 1.

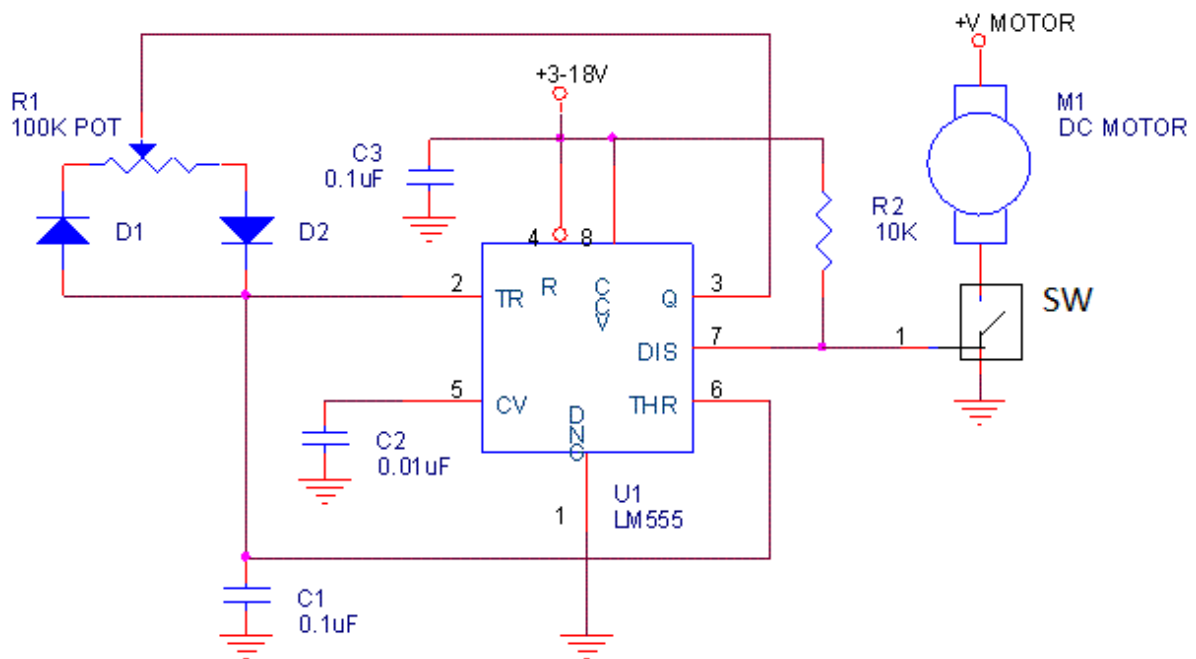


Figure 1-Schematic circuit diagram

We can easily understand by example. On an Off time is referred to as “duty cycle”. The figure -2 shows the waveforms of 10%, 50% and 90% duty cycle signal. As we can see in figure- 2, for 10% waveform 10% duty cycle signal is on and 90% off while a for 90% waveform 90% duty cycle signal is on and 10% off. Here we used a variable pot for varying the duty cycle. The end result of the 555 PWM circuit is send to trigger the IGBT gate to control the speed of motor and it can adjust from 0% to 100% duty cycle with stable control and high efficiency.

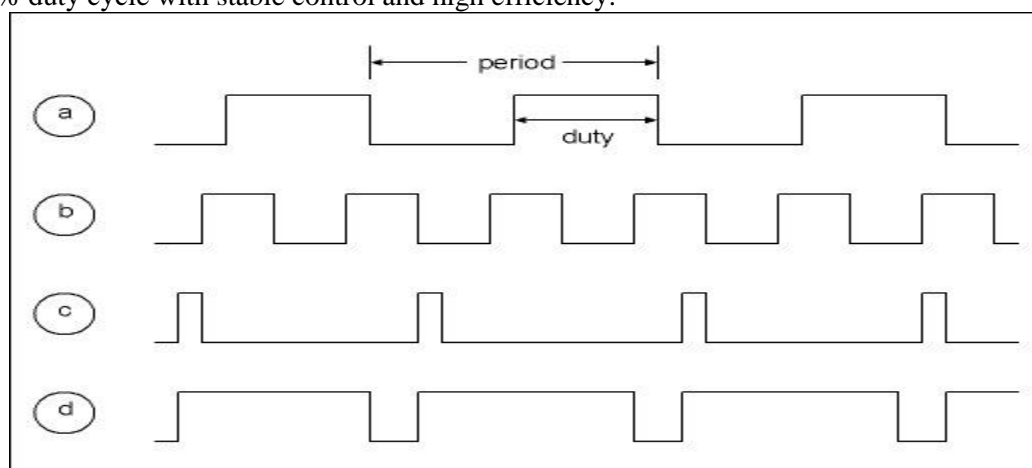


Figure 2- Wave form at different duty cycles

B. Power supply

To generate 12 v Power supply from main source to operate any electronic base circuit, for low voltage we used the step down transformer from 230V AC to 12V DC. After that full wave bridge rectifier is used to convert from AC to DC source for circuit and other components. We can

understand the conversion process of supply from figure 3. During the positive half-cycle of voltage, diodes D2 and D4 are conducting and diodes D1 and D3 are reverse bias. Therefore, current flows through the winding, diode D2, load and diode D4. During negative half-cycles of voltage, diodes D1 and D3 conduct, and diodes D2 and D4 are reverse bias, therefore current flow through diode D3, D1 and load. In each condition the current flow in same direction. As shown in figure- 3.

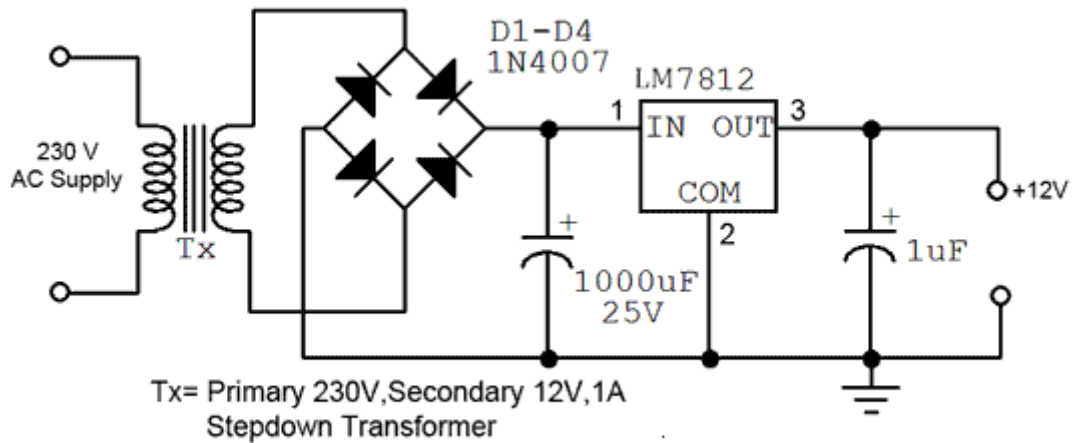


Figure 3-Rectifier schematic diagram

C. Separately excited dc motor

It is the main part of our project as we are controlling the speed of this motor. In separately excited machine field winding is independent of armature winding and the same circuit can also be used to control the speed of shunt motor. The motor available in our college is 1 KW, 230 volt, 4 amp rating and the rated speed of motor is 1500rpm. Equivalent circuit of motor is shown in figure- 4

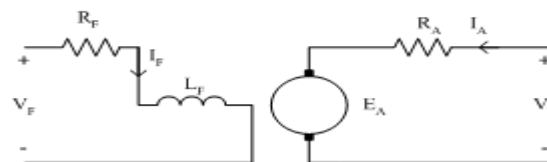


Figure 4-Separately excited motor

D. Optocoupler

Nowadays packing containing an LED and a photodiode, called 'opto-coupler' is used for switching on power or control circuits. Because the light source (LED) and photodiode are physically kept separated (with 2mm) in the package, isolation upto 2500V can be used. Though it is not a main or necessary component but it is useful for precautionary purpose.

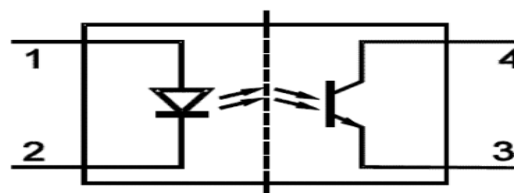


Figure 5-Optocoupler

III. DESIGN METHODOLOGY

Figure- 6 shows the circuit of the DC motor speed controller. 230V AC is converted to 12V DC by using step down transformer and bridge rectifier, IC 7808 is used to regulate voltage and output voltage is 8V. 230V AC is also converted to 220V DC through rectifier GBPC. 555 PWM circuit is used to generate the pulse train to triggered IGBT (25N120) gate. Between IGBT and 555 PWM circuit we use optocoupler for isolation. The chopper firing circuit gets signal from 555 PWM circuit and then by supplying variable voltage to the armature of the motor the desired speed chopper is achieved.

1. IGBT 25N120
2. GBPC 3510 (Rectifier 230AC to 220DC)
3. Diodes 4007
4. Variac pot 100kohm
5. IC 7808
6. 220/12 volt step-down transformer

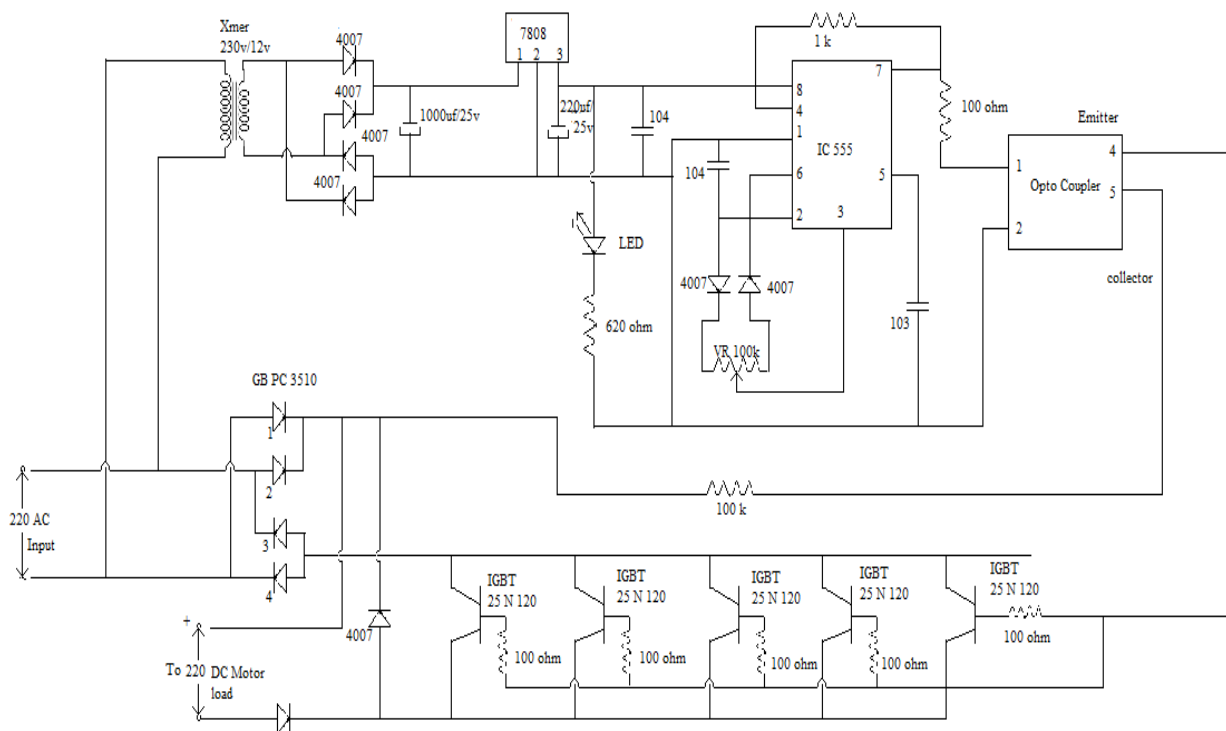


Figure 6-Circuit diagram of project

Below figures 7 and 8 shows hardware schematic diagrams in which step wise figure are mentioned with result.

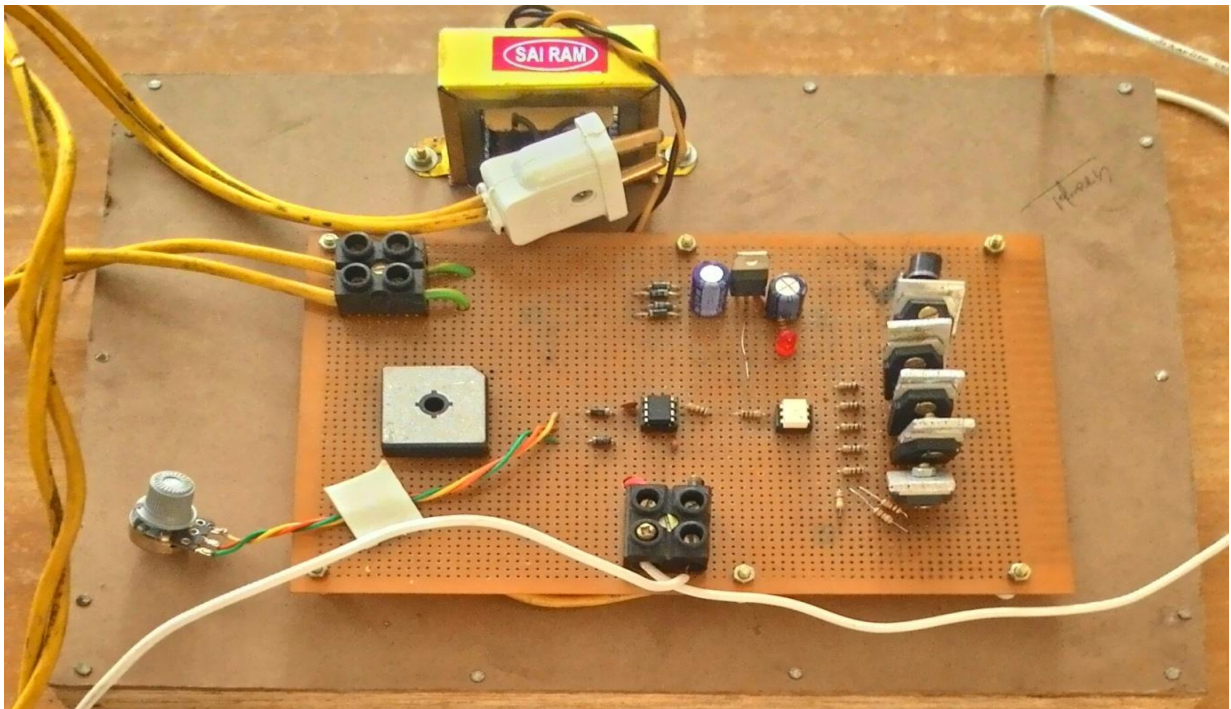


Figure7-Bread board connection diagram during implementation of project



Figure 8-Diagram showing final project with motor and all components combinations.

IV. RESULT AND DISCUSSION

We have made hardware of project and testing is also done, after testing the result is given below:

- I. Speed of 1KW dc motor has been controlled easily by just moving the knob of variable pot.
- II. We have controlled the speed of the motor in between the range 600 to 1200 rpm very easily and efficiently.

Speed can also be controlled below and above the range which is mentioned in point second below rated speed

Table 1- Armature Voltage VS Speed

S. No.	Armature Voltage(V)	Speed(rpm)
1	0	0
2	60	608
3	100	786
4	140	971
5	180	1166
6	200	1256

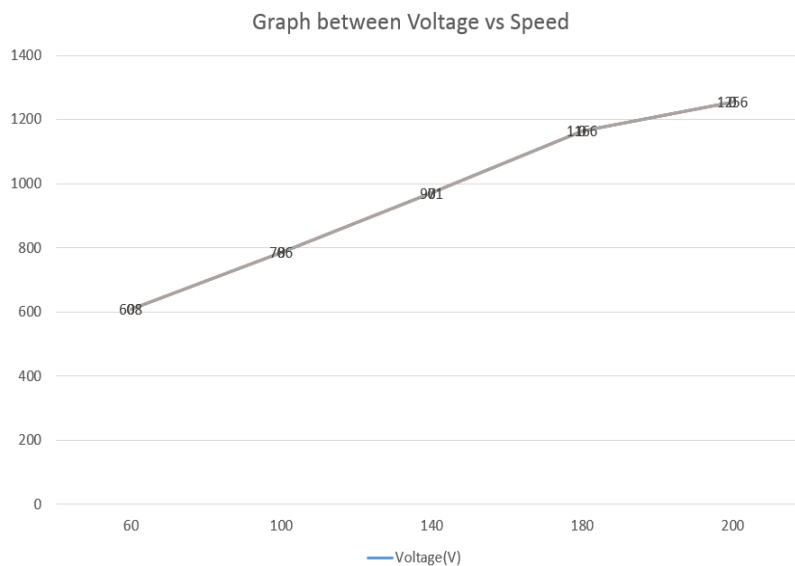


Figure 9. Armature voltage vs. Speed (rpm)

V. CONCLUSION

The designing of a sustainable system to control the speed of separately excited DC motor was successfully implemented in this project. DC motors have speed control capabilities which means that speed, torque and even direction of rotation can be changed at anytime to meet new condition.

- Speed varies directly with armature voltage by keeping field voltage constant.
- The speed of a dc motor has been successfully controlled by using IGBT Chopper.
- The chopper firing circuit gets signal from controller and then by supplying variable voltage to the armature of the motor the desired speed chopper is achieved.
- The IGBT based circuit gives smoother control over the entire speed range as compared with the SCR based circuit.
- 555 PWM circuit based step down IGBT chopper (I Quadrant) utilizing the armature voltage control have many advantages like fast control, low cost and simplified structure

VI. FUTURE ASPECTS

- 1) DC motor plays a significant role in modern industries. They are widely used in industry because of its low cost, less complex control structure and wide range of speed and torque so better future of this project.
- 2) In this project we have used IGBT based chopper for speed control of dc motor, it is a modern technology in solid state field and it provide smooth speed control of motor.

- 3) D.C motors have long been the primary means of electric traction. DC motors are used in many applications like subway cars, battery operated vehicles like electric rickshaws, and for that speed control is necessary. IGBT based chopper is a very effective, easy and economical method of speed control.

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