Closed Loop Speed Control of PMDC Motor

Aarthi. K[1], Alagu Meena. M[2], Deepalakshmi. R[3], Hemalatha. K[4]
[1, 2, 3, 4] Department of EEE
[1, 2, 3, 4] Saranathan college of Engineering, Panjapur, Trichy -12

Abstract- *The speed of Permanent Magnet DC Shunt motor can be controlled from below and up to rated speed using chopper as a converter. The Buck converter chopper is used to vary the speed range of the shunt motor. The chopper firing circuit receives signal from controller and then chopper gives variable voltage to the armature of the motor for achieving desired speed. The controller usesan open –loop relay test, calculates the tuned parameters in an open loop mode of operation before it updates controller parameters and runs the process as a closed-loop system. The controller reacts on a persistent offset error value asa result of load disturbance or a set point change. In closed loop control there are two control loops, one for controlling current and another for speed control. The controller used is Proportional-Integral type which removes the delay and provides fast control. The chopper is designed and simulated using Multisim. Modeling of DC Shunt motor is done. The complete layout of DC drive mechanism is obtained. The designing of current and speed controller is done in order to get stable and fast control of DC motor. The model is simulated using MATLAB(SIMULINK).*

Keywords- DC motor, closed loop, PI controller, Simulink, Multisim.

I. INTRODUCTION

DC drives, because of their simplicity, ease of application, reliability and favorable cost have long been a backbone of industrial applications. DC drives are less complex as compared to AC drives system. DC drives are normally less expensive for low horsepower ratings. DC motors have a long tradition of being used as adjustable speed machines and a wide range of options have evolved for this purpose. Cooling blowers and inlet air flanges provide cooling air for a wide speed range at constant torque. DC regenerative drives are available for applications requiring continuous regeneration for overhauling loads. AC drives with this capability would be more complex and expensive. Properly applied brush and maintenance of commutator is minimal. DC motors are capable of providing starting and accelerating torques in excess of 400% of rated .The main objective of this thesis is to create a model for speed control of DC motor to maintain speed of the motor constant at the required level using a chopper (Buck converter). DC motor is a non-linear device in which if we alter the load of the motor the speed will vary in a non-linear fashion. Making the motor running at constant speed is necessary for industrial applications. This can be possible by using a controller in closed loop system. The controller compares the speed of the motor with the specified reference speed given by the user and adjusts the speed to the reference speed if there is any change in speed of our motor. For example textile mills, paper mills and etc.

II. BUCK CONVERTER

The Buck converter is a voltage step down converter which converts higher input voltage to lower output voltage. These converters are used in marine hoist, trolley,cars, and. forklift trucks. The future electric automobiles are likely to use this type of converter. This DC-DC Buck converter offer smooth control, high efficiency, and immediate response. In this theses, IGBT is used as a switch for this converter. When the switch is OFF, the current will not flows. When the switch is ON, the current will flows through the circuit. In this thesis, the output voltage from the buck converter is given as an input voltage for the Permanent Magnet DC (PMDC) motor. This acts as a supply voltage for the PMDC motor. The Buck converter circuit is given as follows. The readings that is obtained for the buck circuit are tabulated as follows voltage

Duty cycle=50%

Table1. Tabulation for Buck converter

SL.NO.	INPUT VOLTAGE (Vin)	OUTPUT VOLTAGE (Observed)	OUTPUT VOLTAGE (Actual)
1.	14.0	6.3	7.0
2.	18.0	9.13	9.0
3.	21.0	10.4	10.5
4.	24	11.9	12

1. DESIGNING OF BUCK CONVERTER

STEP 1: Calculation of output voltage:
$V_o = V_{in} * D$ D = Duty cycle

STEP 2: Calculation of Inductor value:
$L = (V_{in}*(1-D)*D/\Delta IL$

STEP 3: Calculation of Capacitor value :
$C = (1-D)/(D*L*F^2*(\Delta V_o/V_o))$

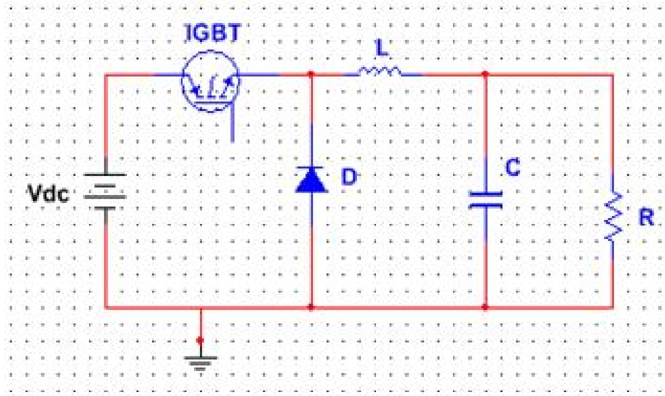


Fig2: Buck converter

III. TIMER CIRCUIT

In this thesis 555 timer circuit is used. LM555 timers are an eight pins IC. 555 Timer IC is a highly stable device for generating accurate time delays. This IC has three modes of operation. They are mono-stable mode, bi-stable mode, a-stable mode. In this project 555 timers is used in a-stable mode. In a-stable mode, a square wave is produced by varying Ton and Toff using pots. In this thesis, IC 555 is used as clock. The clock has 2 pots are used. One of the pot is used to adjust the frequency of the square wave and the other is used to adjust the duty cycle. The supply for 555 Timer circuit is from the 5v power supply circuit.

The Ton and Toff are set by the following formulae.

$T_{on} = 0.693*(Ra+Rb)*C$
$T_{off} = 0.693*Rb*C$
$T = 0.693*(Ra+2Rb)*C$

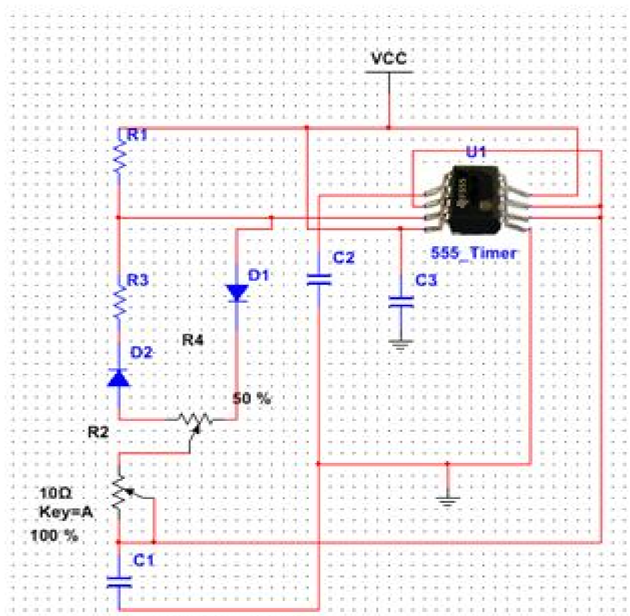


Fig3. 555 Timer circuit

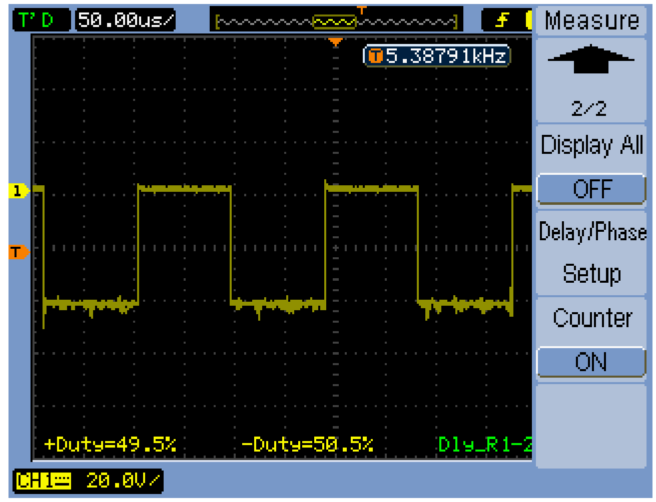


Fig4. 555 Timer output

IV. GATE DRIVER CIRCUIT

This is a power amplifier which accepts a low power input from the controller and produce a high current drive input for the IGBT in the buck converter. Gate driver consist of a level shifter in combination with an power amplifier. Here gate driver IC is used because it is the simplest smallest and lowest cost solution to drive IGBT up to 1200v in applications up to 12kw, these IGBT'S provide full driver capability with extremely fast switching speeds designed in ruggedness and low power dissipation. They generate current and voltage necessary to turn IGBT on and off from the output of the controller so that we can save 30%in part count and up to half the board space of transformer based solutions for example if the input is 3.3v logic level signal and output currents are up to 4v.Here TLP 250 IC is used since it is a optically isolated driver meaning that input and output are optically isolated (i.e.) input stage is an LED and the receiving output stage is light sensitive.

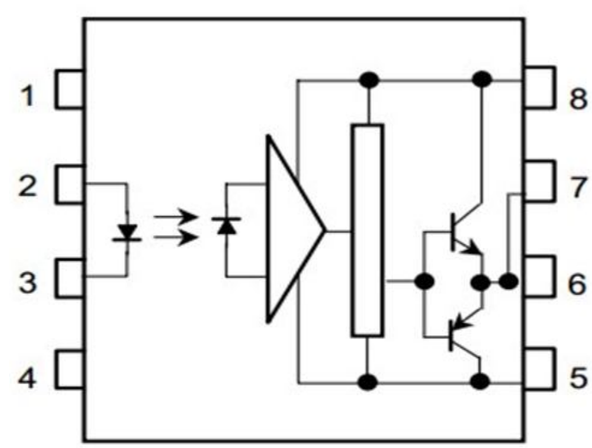


Fig5: Internal diagram of TLP250

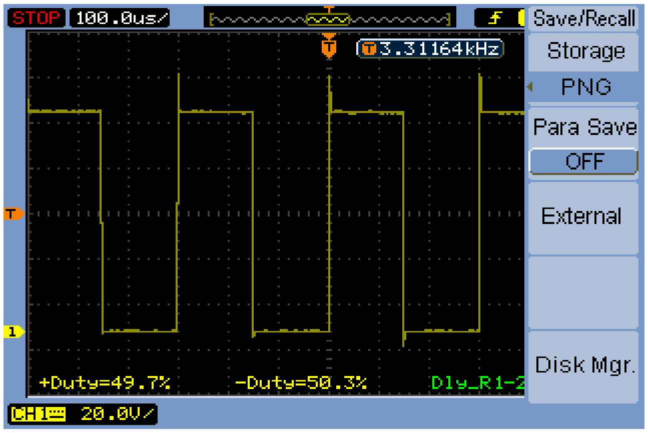
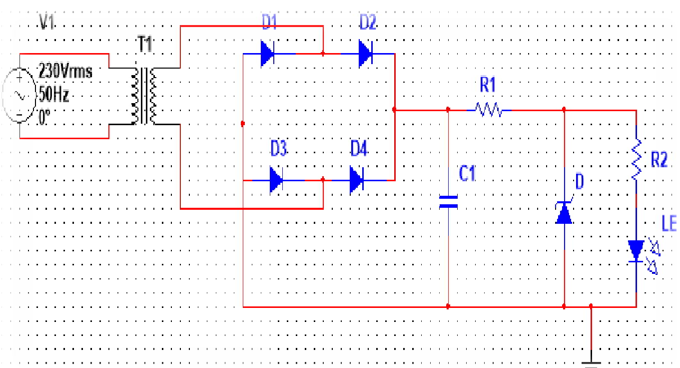


Fig6. Output of TLP250

V. POWER SUPPLY

Step down transformers are used which step downs 230v to15v and 12v. A Rectifier is used to convert the ac to dc andthe output of rectifier is fed to the integrated IC's (IC7812and IC7805) to get the required output of 12v and 5v.Then a combination of inductor and capacitor is used to get the pure DC output of 12v and 5v. The 5v dc supply is used to power the pulse width modulator circuit and the 12v dcsupply is used to power the gate driver circuit.



VI. CONTROLLER DESIGN

The controller is used in closed loop system in order to keep the speed of the motor at any desired value under load varying conditions. It is possible by providing an inner current loop and outer voltage loop. There are totally 3 types of controllers,

1) P Controller
2) PI Controller
3) PID Controller

Load is balanced by the product of error speed and the gain, which can be done by the "**proportional control**" but this control has limited use since it never has the capacity to run the motor exactly at the set point speed. The PI controller made change in the output as fast as the error arise. Integral action takes finite time but has the capability to make the steady state error to zero. To apply an additional correction to the output we can use the rate of change of error speed. This is known as derivative approach. In this project PI Controller is used for closed loop control.

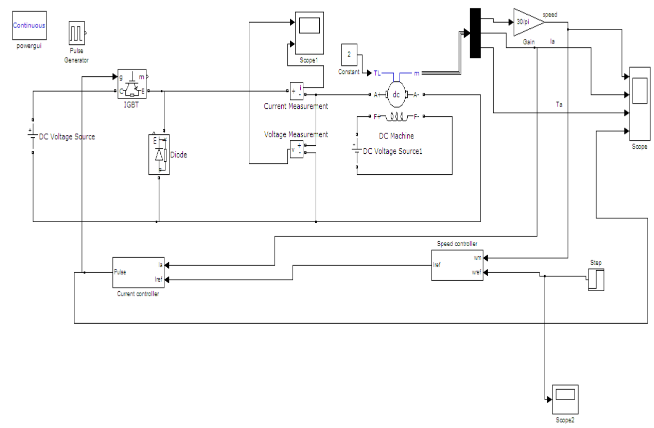
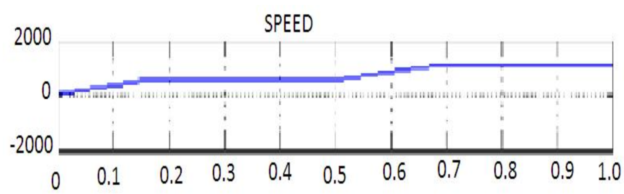
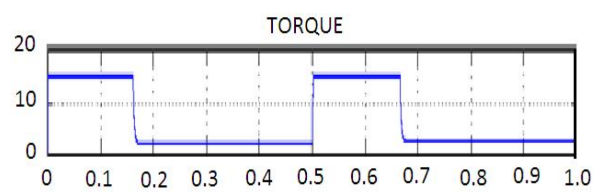
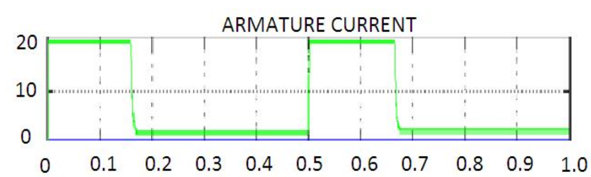


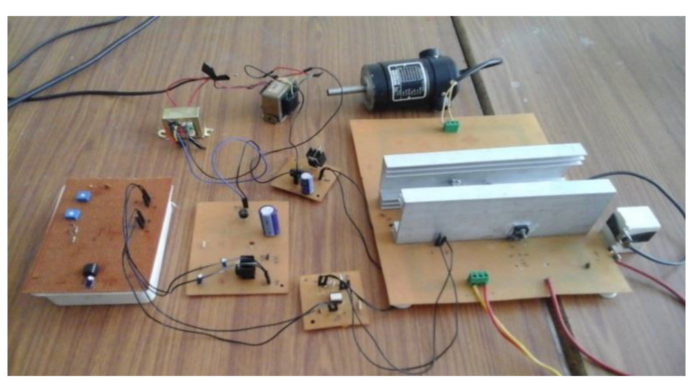
Fig8. Closed loop speed control in SIMULINK







VII. HARDWARE



VIII. CONCLUSION

The open loop speed control of DC motor has been simulated in multisim software and implemented practically. The PI controller for the DC motor speed control has been simulated. It is found that for the control of a first order plant like the DC motor, the PI controller is sufficient to obtain the desired results. The future work will aim at designing of hardware for the PI controller.

REFERENCES

[1] Bimbhra P.S power electronics., New Delhi Khanna publishers

[2] Dubey G.K fundamentals of Electric Drives New Delhi.narosa publishing house.

[3] Gopal. M control systems principles and designs New Delhi Tata McGraw hill publishing company limited.

[4] Rashid M.H power electronics, prentice hall of India.

[5] Datasheets LM2907N, LM339, National Instruments.

[6] Datasheets TL084,TL071, Texas Instruments.

[7] Electric Motor Drives Modeling analysis and control, R Krishnan.

[8] Chinnaiyan V. Kumar, Jerome Joritha, Karpagam, J. S.Sheikh Mohammed, Design and Implementation of High Power DC-DC converter and speed control of dc motor using TMS 320F240DSP, Proceedings of India International Conference on Power Electronics, 2006.

[9] Bose B.K., Power electronics and motor drives recent technology advances, Proceedings of the IEEE International Symposium on Industrial Electronics, IEEE, 2002, pp 22-25.

[10] www.wikipedia.org.

[11] MATLAB and SIMULINK Version 2009a, the MathsworksInc, USA.