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CHOPPER FED SPEED CONTROL OF DC MOTOR USING PI CONTROLLER

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Abstract-This paper presents a speed control of a separately excited DC motor by using PI (Proportional Integral). The speed of the separately excited DC motor can be controlled to below and above the rated speed by using buck converter. It can be varied above the rated speed by field flux control and below the rated speed by armature terminal voltage control. The chopper gives variable voltage to the armature of the motor for achieving desired speed using PI controller. The reason behind using PI controller is, it removes the delay and provides fast controller. The modelling of separately excited DC motor is done and the complete layout of DC drive mechanism is obtained. To produce the PWM pulses for chopper switch, we compare the reference signal with triangular carrier signal. The MATLAB/SIMULINK software is used to construct the simulation model. The simulated output parameters of the DC motor such as armature current, field current, voltage, speed and torque. The results are also verified by constructing an experimental prototype 12v, 24w DC motor and implemented the Proportional Integral controller in it.

Keywords-DC motor, separately excited DC motor, chopper, Proportional Integral controller, Armature Voltage control, PWM generator, DC/DC Buck converter

1. INTRODUCTION

An electrical drive system consists of electric motors, power circuit, controller and energy transmitting shaft. In modern electric drive system power electronics converters are used as power controller. Electric drives are mainly 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 . The DC motors are used extensively in adjustable speed drives and position control system. The speed of DC motors can be adjusted by below the rated speed and above the rated speed. Their speed below rated speed is controlled by armature voltage . The development of high performance motor drives is very essential for industrial applications. A high performance motor drive system must have good dynamic speed command tracking and load regulating response . The DC drives are widely used in applications requiring adjustable speed control, frequent starting, 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 . There are various types of speed control techniques are available for DC drives, such as, armature voltage control, field flux control and armature resistance control. For controlling the speed and current of DC motor, speed and current controllers are used . The main work of controller is to minimize the error and the error is calculated by comparing output value with the set point. This paper mainly deals with controlling the DC motor speed using chopper as power converter and Pl as speed and current controller. Now days Induction motors, brushless D.C motors and synchronous motors have gained widespread use in electric traction system. Hence Dc motors are always a good option for advanced control algorithm because the theory of DC motor speed control is known more than other types. The speed control techniques in separately excited DC motor, by varying the armature voltage for below rated

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speed . The power semiconductor devices used for a chopper circuit can be force commutated thyristor, power BJT, MOSFET, IGBT and GTO based chopper are used. It having very low switching losses that means total voltage drop has 0.5V to 2.5V across them The various controllers that can be used in speed control operation are available. Proportional plus Integral (PI) is the most preferred controller, which are designed to eliminate the need for continuous operator attention thus provide automatic control to the system.

2. DC/DC CONVERTERS

DC-DC converters are widely used to efficiently produce a regulated voltage from a source that may or may not be well controlled to a load that may or may not be constant. This paper briefly introduces DC-DC converters, notes common examples, and discusses important datasheet parameters and applications

DC-DC converters are high-frequency power conversion circuits that use high-frequency switching and inductors, transformers, and capacitors to smooth out switching noise into regulated DC voltages. Closed feedback loops maintain constant voltage output even when changing input voltages and output currents. At 90% efficiency, they are generally much more efficient and smaller than linear regulators. Their disadvantages are noise and complexity.

DC-DC converters come in non-isolated and isolated varieties. Isolation is determined by whether or not the input ground.Four common topologies that makers might find useful are the buck, boost, buck-boost, and SEPIC converters.A buck converter steps a voltage down, producing a voltage lower than the input voltage. A buck converter could be used to charge a lithium ion battery to 4.2 V, from a 5 V USB source.A boost converter steps a voltage up, producing a voltage higher than the input voltage. A boost converter could be used to drive a string of LEDS from a lithium cell, or provide a 5 V USB output from a lithium cell.

A buck-boost converter steps a voltage up or down, producing a voltage equal to or higher or lower than the input voltage. A buck boost could be used to provide a 12 V output from a 12 V battery. A 12V battery's voltage can vary between 10 V and 14.7 V. A buck boost could also power an LED from a single cell. An LED forward drop is as high as 3 V. A lithium battery cell can vary between 2.5 and 4.2 V. There are buck-boosts that produce positive and negative voltages.

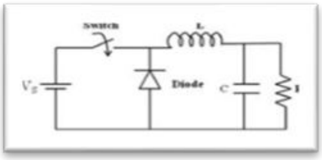

Fig.1. Buck converter

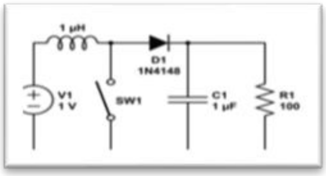

Fig.2.Boost converter

3. CIRCUIT DAIGRAM

In that circuit diagram describe the mainly three blocks. They are converter block, motor block and controller block. In that three block connections are given to the Fig.3. Additionally comparator will be used int the block it will compare the actual speed to reference speed and to produced error signal. The main converter circuit it will be produced the fixed DC to variable DC power supply. It will be to given the motor circuitry part. Up to DC motor the part will be consider as the power circuit. Next part of DC motor is measuring work will be done. After the measuring work we are implement the error detection and correction process. At last the circuit diagram will be taken as the feedback control circuit. In each part considering a different work of the speed, current and torque will be controlled Here initially given the 240V DC supply on the Vs side. It will connect to the back converter section. In that buck converter output is given to the armature of the DC motor. Here using separately excited DC motor in that motor field winding are having external DC supply in that range of 300V DC motor speed will be measured by using on tachogenerator, its output speed is consider the actual speed of the motor. In comparator compare the

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both actual and reference speed. It produced error signal is fed to the PI controller. In that PI controller rectify the error signal and produced constant signal, PWM generator is comparing the triangular carrier and output signal of the PI controller. At last the output PWM pulse is given to the buck converter as a feedback.

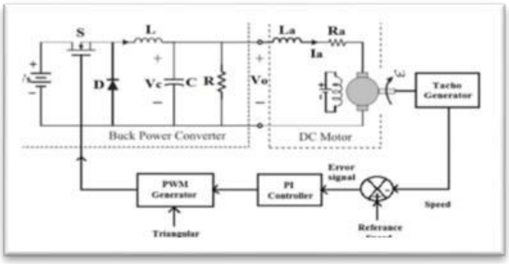

Fig.5.Circuit Diagram.

4. SEPARATELY EXCITED DC MOTOR

Fig shows the equivalent circuit of the separately excited DC motor. The separately excited DC motor has armature and field winding with separate supply. The field windings of the DC motor are used to excite the field flux. Current in armature circuit is supplied to the rotor via brush and commutator segment for the mechanical work. The rotor torque is produced by interaction of field flux and armature current.

When a separately excited DC motor is excited by a field current of i, and an armature current of i, flows in the circuit, the motor develops a back EMF and a torque to balance the load torque at a particular speed. The field current i, is independent of the armature current i, Each winding is supplied separately. Any change in the armature current has no effect on the field current.

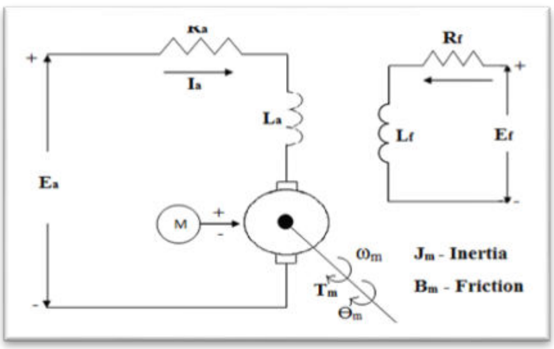

Fig.6.Equvivalent Circuit Of Separately Excited DC Motor

PI CONTROLLER

The PI controllers are widely used in industrial practice for more than 60 years. The development went the pneumatic through analogue to digital controllers, but the control algorithm is in fact the same. The Pl controller is standard and proved solution for the most industrial application. The PI algorithm computes and transmits a controller output signal every sample time (T), to the final control element. Pl controllers have two tuning parameters to adjust and the parameters are current I and torque T. PI controller will not increase the speed of response, so it maintain the constant speed of the DC motor. PI controller is mainly used to eliminate the steady state error resulting from P controller. However, in terms of the speed of the response and overall stability of the system, it has a negative impact. This controller is mostly used in areas where speed of the system is not an issue. Since PI controller has no ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations. If applied, any amount of I guarantees set point overshoot. PI controllers are very often used in industry, especially when speed of the response is not an issue.

The Pl controller for the current loop using bode analysis or other control system design tools. The next step is usually the design of the speed controller. The 0-db intercept of 1/1s (1+Tis) is normally much too low. The main reason is its relatively simple structure, which can be easily understood and implemented in practice, and that many sophisticated control strategies, such as model predictive control, are based on it. An application with large speed capabilities requires different Pl gains than an application which operates at a fixed speed. In addition, industrial equipment that are operating over wide range of speeds, requires different gains at the lower and higher end of the speed range in order to avoid overshoots and oscillations. Generally, tuning

the proportional and integral constants for a large speed control process is costly and time consuming. The task is further complicated when incorrect PI constants are sometimes entered due the lack of understanding of the process. The control action of a proportional plus integral controller is defined as by following equation:
u (t) == Kp+ Ki

where
u (1) is actuating signal. e (t) is error signal. Kp is Proportional gain constant. Ki is Integral gain constant. The Laplace transform of the actuating signal incorporating in proportional plus integral control is

U(s) = Kp + Ki

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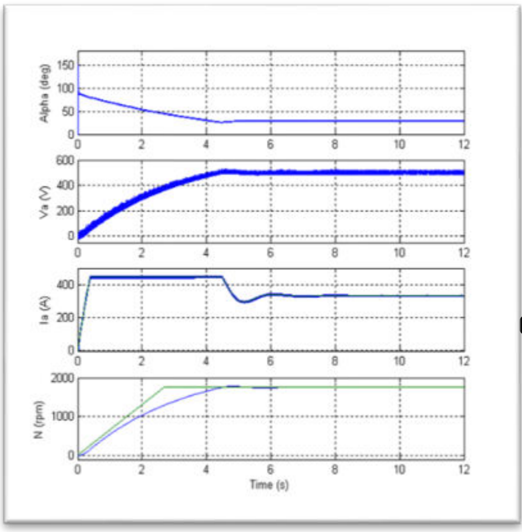
The block diagram of closed loop control system with PI control of DC motor system is shown in Fig.5. The error signal E(s) is fed into two controllers, i.e. Proportional block and Integral block, called PI controller. The output of PI controller. U(s), is fed to DC Motor system. The overall output of DC drive, may be speed or position, C(s) is feedback to reference input R(s). Error signal can be remove by increasing the value of Kp, K.



ON

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and low losses. Here SHP. 240V, 1750 rpm separately excited DC motor and additionally 300V DC supply are given to the field. To take the constant load of the circuit consider its kad 20Kg at constantly. In that simulation, there are four motor parameters are monitored by using displays, such as armature voltage, armature current, torque and speed of the DC Motor

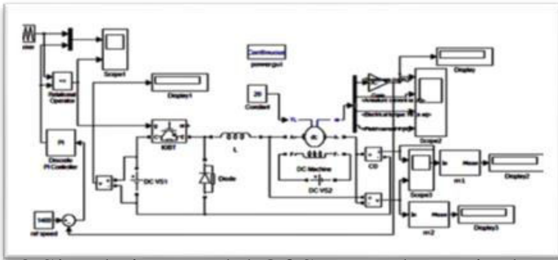

Fig.8.Simulation Model Of Separately Excited Dc Motor

Here the freewheeling diode is to maintain continuous current path in the armature. The discrete PI controller gain is chosen by the trial and error method. In that PI controller output is act as the modulation index of the converter. The relational operator can be comparing the reference signal to the carrier signal. To set the maximum reference value of PI controller output is 0.9V. When the carrier signal voltage is more than reference voltage that time IGBT go to OFF or 0 state. Otherwise the IGBT maintain the ON or I state. The Fig.7 shows the PWM Pulse generation for the converter. This paper successfully done the simulation for the chopper fed speed control of separately excited DC motor using PI controller. The outputs of the simulation results are sho

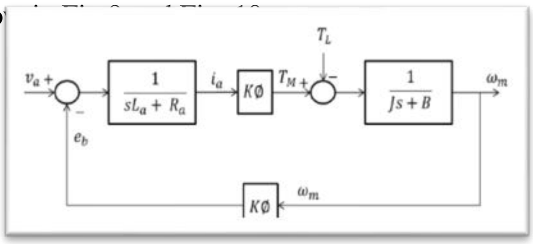

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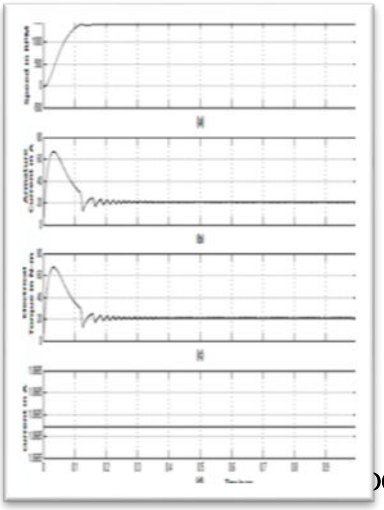
Fig.9.A Simulation Output Of Dc Motor Armature Current And Converter Output Voltage



C Motor

CONCLUSION

The speed of a DC motor has been successfully controlled by using Chopper as a converter and Proportional Integral as the controller for closed loop speed control system. Initially a simplified closed loop model for speed control of DC motor is considered and requirement of PI controller is studied. Then a generalized modeling of separately excited DC motor is done. The MATLAB SIMULINK model shows good results under below the rated speed during simulation. The simulation output creates the constant armature voltage and constant field current that time speed and torque of DC motor also produced constant output. Here using buck converters the switching losses will be reduced and motor efficiency are reach approximately more than 95%.

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