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Design and Implementation of speed control Induction Machine by Using Interface programming

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Abstract

This article describes the Systematic development of the analysis design and testing by simulation the closed-loop speed control of separately excited dc motor drive system. The motor controlled armature voltage is supplied from a three-phase controlled bridge converter. Closed-loop control is analyzed by using transfer function technique and the necessity of an inner current control loop is demonstrated. Design of both a proportional and proportional- integral controllers are outlined by using transfer function technique. The feed forward loop is also presented for load case. The simulation speed and current responses are presented in this project for speed proportional-current proportional controllers and speed proportional plus integral -current proportional controllers. The system responses in load case are presented and the sudden drop in the speed response is accessed by using feed forward-loop to reduce the load disturbances.

Keyword: ***speed control, simulation, Interface programming, thyristor, motor***

1. Introduction

D.C motors have been used in variable-speed drives for along time. The versatile control characteristics of a dc motor have contributed to their extensive use in industry [1]. Control over a large speed range for both below and above the rated speed can be easily achieved. The speed of the dc motor is relatively easy to control by either its armature voltage; it's field voltage or both, depending upon the desired performance characteristics of the drive. The methods

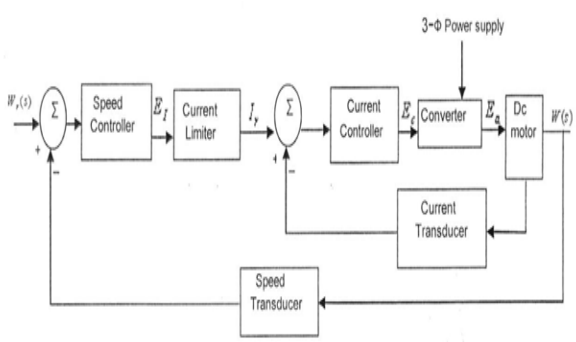

Fig.(1) : A basic block diagram of a speed control system of a dc motor

of control in a dc-drive are simpler and less expansive than those of alternating current motors.

In the late 1950s solid-state devices, silicon diodes, and silicon-controlled rectifiers (SCR) became available in the market at economic prices. The classical M-G set (electromechanical control) has been replaced by thyristorized power converter (electronic control) [1].

2. PIP Controllers

- The industrial controllers may be classified according to their control action as[2]:
- Two position or on-off controllers
- Proportional controllers
- Integral controllers
- Derivative controllers
- Proportional-plus-integral controllers
- Proportional-plus-derivative controllers

Proportional-plus-integral-plus-derivative controllers

4. System Analysis and Design

In this section presents a systematic development, using transfer function techniques of a closed loop speed control scheme and an outline of the control design. Each block in the Fig.(1) is discussed in this chapter and described by a mathematical model to enable us to analyze, design and frequently testing the system. The speed controller is chose proportional controller and proportional plus integral controller in other times. The values of speed controller are designed for both types of controller (proportional controller and proportional-integral controller). The current controller is designed as proportional controller. The necessity of the current control loop and current controller is shown in this figure (1).

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4. 1Microprocessor Based DC Motor Control

A conventional analog control scheme implemented in dc drives consists of an outer-control loop and an inner-current control loop. The analog control method has several disadvantages such as; difficulty in accurately transmitting the analog signal, errors due to temperature component aging, drift and offset of the analog components, extraneous disturbances, and soon. A digital control system, on the other hand, is free from this disadvantage. The microprocessor, as the brain of a system, can digitally control the angular velocity of the motor. In addition it can perform other tasks that may be needed in the application. In other words the microprocessor controllers are generally carry out in a supervisory role, acting as an intelligent link between the plant

and the conventional thyristor phase controlled converter and supplying to them latter the appropriate control signals advantages of replacing hardware circuits by microprocessor controllers for a variable speed drive are reducing the size and cost of the hardwired electronics, and having more precise, stable and easy to maintain dc- motor drives [3]

4.2 D.C Motor Transfer Function

Separate excitation of a separately excited dc motor makes the speed control of the motor relatively easy. Consider the separately excited dc motor with armature voltage control shown in Fig. (5). the voltage loop equation is. These relationships are shown in a block diagram form in Fig. (2). note that the feedback loop present in the form of the back EMF. This provides the moderate speed regulation inherent in the separately excited dc motor. [4]

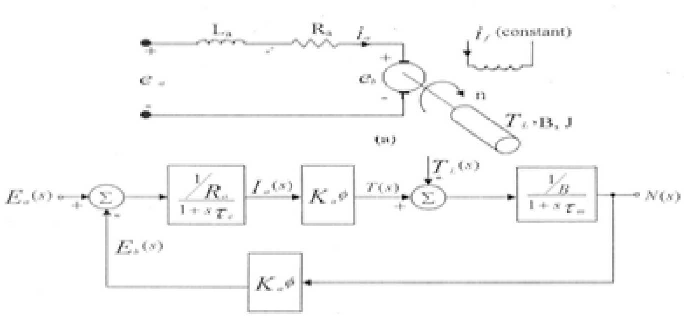

Fig. (2) Development of motor transfer function, (a) Separately excited dc motor model, (b) Functional block diagram

4.3 Closed-Loop Control

DC motors are widely used in many speed-control drives. Open-loop control is sending a signal to the motor, but not sensing the operation of the motor, hence, the control system cannot verify the exact operation of the motor (i.e. make it move at a certain speed or to a certain location). A closed-loop control system senses the rotation of the motor shaft, and/or the voltage and current delivered to the motor.

This information can allow the speed, location of the motor to be easily found. Open-loop operation of dc motors may not be satisfactory in many applications. If the drive requires constant speed operation the firing angle has to be changed to maintain a constant speed. This can be achieved in a closed-loop control system. A closed-loop system generally has the advantages of greater accuracy, improved dynamic response,, and reduced effects of disturbances such as loading. When the drive requirements include rapid acceleration and deceleration, closed-loop control is necessary. In a closed-loop control system even the drive characteristics can be modified. Thus, the system can be made to operate at constant torque or constant horsepower over a certain speed range, a requirement in traction systems. In fact, most industrial drive systems operate as closed-loop feedback systems. The block diagram of a microcontroller based closed-loop speed control system of a separately excited dc motor fed from three-phase fully controlled bridge converter is shown in Fig. (3). If the motor speed decreases due to application of additional load torque, the speed error £ increases, which increase the control signal J7. This in turn changes the firing angle of the converter, and thus increases the, motor armature voltage. An increase in the motor voltage develops more torque to restore the speed of the drive system. The system thus passes through a transient period until the developed torque matches the applied torque at the reference speed. In this project the closed-loop system is used instead of the open-loop control system. In the following sections, a controller parameter design is presented for both speed and current control loops. [4]

4.4Current-Controlloop

A change in the reference speed may result in a large sudden change in current .This transient over current is undesirable from the viewpoint of converter rating and protection. This is particularly the case of starting or other large changes. Therefore the current must be limited to some maximum allowable value. The current limiting is an integral part of a variable speed drive and suitably designed so that its maximum value corresponds to the maximum permissible current of the thyristors-motor setup. The current limiting cannot be done on the speed error signal because the motor voltage (armature voltage) is controlled by the speed error signal, therefore, any attempt to clamp this speed error will limit the motor voltage. However, a current limiting can be implemented if we first construct an inner current control loop using the clamped speed error as the current reference. The current control loop provides fast response and overcome the adverse effects of supply disturbances. The electrical time constant of the armature is small compared with the mechanical time constant and therefore the armature current rather than the speed is subject to almost instantaneous variations due to occurring disturbances. As a consequence, with the current loop

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present, the corrective action will be faster and the speed regulation will be improved. Fig. (3) represents the current control loop, the nonlinearity of the system due to converter can be overcome by using a proper firing control scheme to fire the SCR_s, a linear relationship between the control voltage (Ec) and the armature voltage) can be obtained. For current controller operation the back emf (Eb) can be assumed-constant because the latter depends on the speed (N), and since the mechanical time constant is greater than the electrical time constant, then the speed can be considered constant. Hence the current control loop can be reduced to the system shown in Fig. (6). The parameters of the test motor are given in Appendix-A with the controller parameters, which are determined by the design. The current sampling period (Ti)

4.5 Speed Control Loop:

From this Fig. (6.a) shows the digital speed control loop. If an actual speed of a separately excited dc motor can be measured and a speed signal can be fed back, the speed error signal (n) can be calculated by comparing the reference speed with the measured speed (actual speed) in the microcontroller. This error signal represents the input signal to the speed controller to adjust the reference the current control loop, consequently to control the armature voltage. In designing the speed controller, three assumptions have been made:

The current control loop can be considered to be a first order system with new electrical time constant. This time constant is very small when compared with the mechanical time constant, so it can be neglected for simplicity.

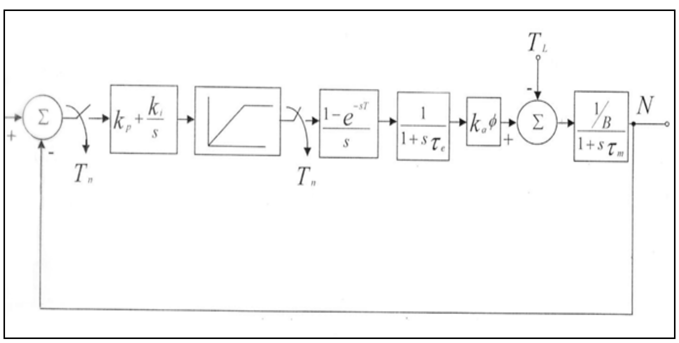


Fig.(3) **Discreet speed control loop**

5. Result

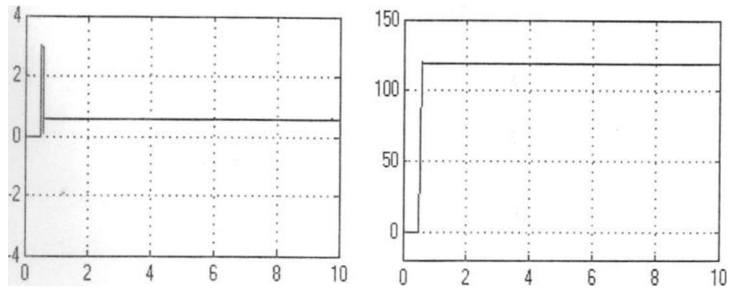
5-1 No Load Results

5.1.1 Proportional Speed -Proportional Current Controllers

The speed and current responses for step change in speed reference for Kp = 14.169, Ki=19.407

Shown in Fig.(4a,b). The current and speed controller are operational type controller, with reference speed equal to 120 rad/s. The limit value of current limiter is 3A. It's clear from Fig.(7a,b) the current is limited at 3 A, where the limiter prevent the suddenly.

. mp of current response at the starting



(a) (b)

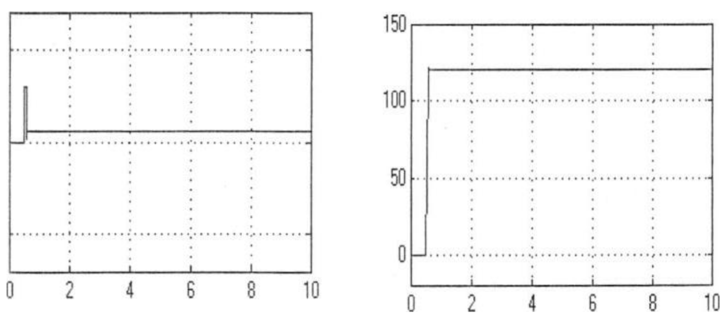
Fig.(4)a ,b Response of proportional control to step change in speed reference (a)current response (b) speed response

5.2Proportional Integral Speed -Proportional Current Controllers

From the speed response, the rise time is equal to 0.067s, while the peak time s 0.592s.The overshoot of the speed response is 0.467% and the steady state error equal to 0.370.

5.3Proportional Integral Speed -Proportional Current Controllers

To reduce the steady state error and the peak time, the speed controller is designed as Pi-controller with transfer function, Where the r_2 =0.0707, r =0.1414.The current controller is proportional type controller with constant value 14.169, Fig.(5) shows the speed and current response of speed control system for tip change in the response speed.



(a) (b)

Fig. (5) Response of Pl-control to step change in speed reference (a) current response, (b) speed response

From the speed response the rise time is equal to 0.067s, while the peak time is 0.25 Is. The overshoot of the speed response is 1.5% and the steady state error equal to zero**.**

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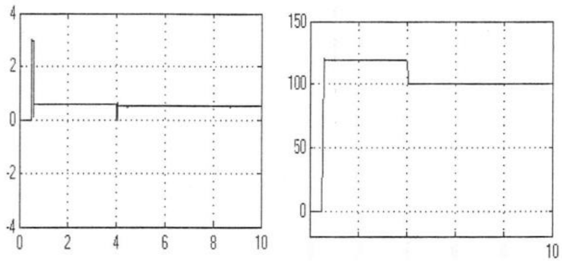
5.4 Step Increasing and Decreasing of Reference Speed

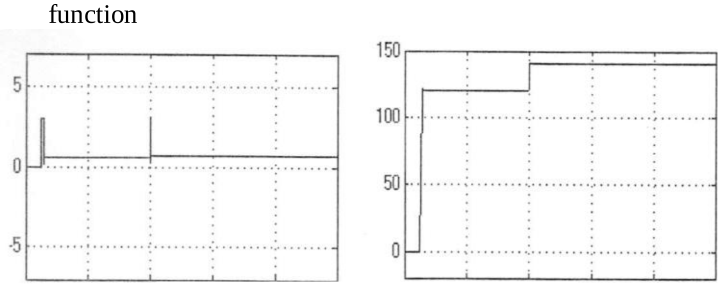
If the motor reference speed increase, the speed errors increases. This in turn changes the firing angle of the converter, and thus increases the motor armature voltage .An increase in the motor voltage develops more torque to increase the motor speed to reach approximately to the reference speed .Fig (5) shows the speed and current responses for step increasing in the reference speed, while Fig.(6) shows the system response for decreasing case. When the speed and current controllers are proportional type controllers with value k, = 14.169,k_s =19.407.



(a) (b)

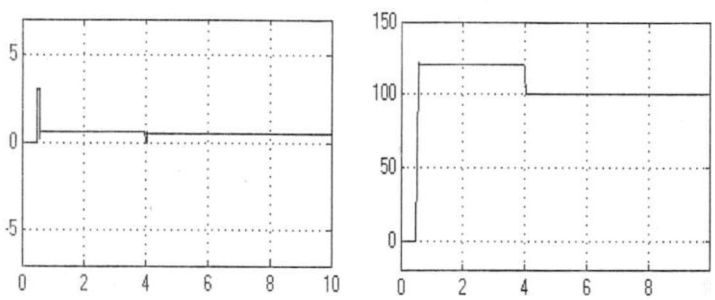
Fig.(6) Response of P-control to step increasing in speed reference (a) current response (b) speed response

From the fig.(6) and Fig(10) are show the current and speed response for step increase and step decrease in reference speed respectively. Where the speed controller is proportional plus integral type controller with the transfer function



(a) (b)

Fig.(7)Response of PI- control to step increasing in speed reference (a) current response (b) speed response



(a) (b)

Fig. (7) Response of PI control to step decreasing in speed reference (a) current response (b) speed response

6.1 Proportional Speed Controller

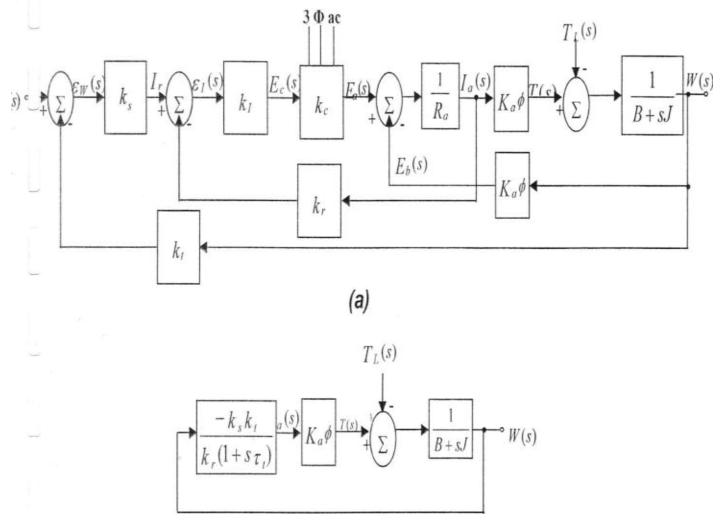


Fig.(8) Effect of load torque disturbances, (a) Functional block diagram, (b) Simplified Functional block diagram

Fig.(8a) shows the complete block diagram for the speed loop with proportional speed and current controllers. If changes in the reference speed W_r *are neglected, Fig.(8b).*

7. Load-Results

7.1 Proportional Speed -Proportional Current Controllers:

We saw the Fig.(9) shows the current and speed responses for speed control system with load torque applied at /' = 4sec. The system is tested with speed and current controllers are proportional type *controller where* k, *=14.169 and* k_s *=19.407 .From the speed response, the steady state error defer applied the torque is very small, but is increased to become (8.1) after applied a load to the dc-motor. The steady state error of the speed response in speed control dc motor system is reduce by replacing the proportional speed controller by proportional-plus-integral speed controller , However, the steady state error is reduced from 8.1 to 0.31 as show in Fig.(9).*

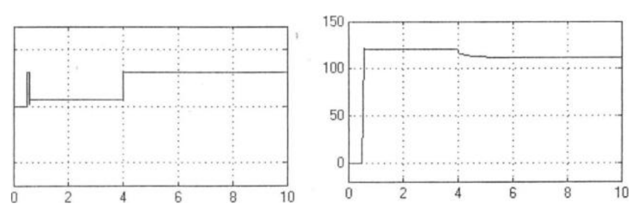


Fig.(9) Response to step increase in load torque with Pl-controller (a) current response,(b)speed response

7.2 Feed Forward Loop

To reduce the dynamic speed variations of dc motor due to the step change in load torque, a feed forward scheme is presented as shown in Fig.(10). In this scheme.

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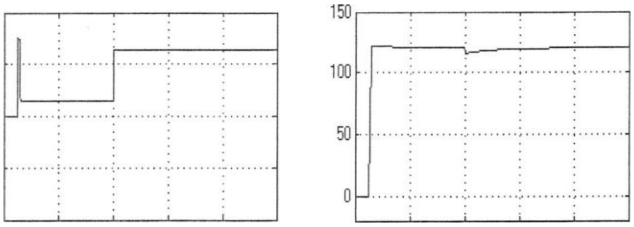

Fig. (10): Speed control of dc motor with feed forward loop.

8. Conclusion

In the present work a closed-loop analog speed control of dc-motor has been described. The closed-loop control technique is used instead of open-loop technique to increasing the accuracy, improved the dynamic response, and reduction of the effects of disturbances such as sudden loading. A transfer function technique is used to design the controller parameters. The current limiter is used to limit the armature current to some maximum allowable value (3A).The simulation response of the system is found for P and PI controllers. The steady-state error is reduced by using Pi-speed controller. The response of the system for step increasing and decreasing of reference speed is getting and found that the output of the system w(s) is tracked the reference speed wr. Table (1) shows the characteristics of speed response of proportional and proportional integral controllers. An improved response is achieved by using a feed forward loop with load torque case. The theoretical responses (simulation results) are not the same of practical responses, because some time constants are neglected in the system analysis, but the results are approximately closed to the practical results. The analog speed control of dc-motor is very easily in the analysis phase and in the simulation phase. But very complex experimentally, sometime need to change or replace some elements of the circuit to get the system response and specification, therefore we conclude that the digital speed control system is better than analog scheme.

Table (1)

Controller Type		**Rise time**	**Peak time**	**overshoot**	**Steady state error**	**Not**
Current	Speed					
P	P	0.067	0.592	0.467%	0.370	NO Load
P	PI	0.067	0.0251	1.5%	0	NO Load

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