IDENTIFICATION OF CASCADE CONTROL DC MOTOR SYSTEM USING NEURAL NETWORK

JULIA BINTI ABU BAKAR

B

POWER ELECTRONICS AND DRIVE

APRIL 2009

"I hereby declared that I have read through this report entitle "Identification of cascade control DC motor system using neural network" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronics and Drive)"

Signature : ....

Supervisor's Name : En. Muhammad Nizam bin Kamarudin

Date : 8/05/09

IDENTIFICATION OF CASCADE CONTROL DC MOTOR SYSTEM USING NEURAL NETWORK

JULIA BINTI ABU BAKAR

This Report Is Submitted In Partial Fulfillment of Requirements for the Degree of Bachelor in Electrical Engineering (Power Electronic and Drive)

Fakulti Kejuruteraan Elektrik
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

April 2009

"I declare that this report entitle "Identification of cascade control DC motor system using neural network" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

Signature : ....

Name : Julia binti Abu Bakar

Date : 06/05/09

To my mom, my parents, my sister, my friends and my lover

ACKNOWLEDGEMENT

First of all, I am grateful because I was given a chance to take part in this project. This is a wonderful opportunity for me to harness my skills in both the programming and hardware area.

In this acknowledgement segment, I wanted to thank is my project supervisor, En. Muhammad Nizam bin Kamarudin for allowing me to do this project. He had given me some idea on how to do our project and also on writing this dissertation. He has taught and has guided us along the way in doing this project. He also had given some inner idea in completing this project. Through his guidance, I was able to complete this project as expected.

And for the person that I forgot to mention in this segment, I would like to say a big thank you for you all. Without the support and help that you all gave me, this project would not be so faster to accomplish.

ABSTRACT

The purpose of this project is to identification of cascade control system using neural network. Beyond this project, the main objective that going achieve are to identify the response of speed and current of DC motor using neural network. Block diagram of cascade control system consists of DC motor, DC-DC converter, current controller and speed controller. PI controller is use to carried out the current control, but further increase PI controller parameters, controlled process input can be unstable. It's quite difficult to tune the PI parameters by manual way. To overcome this problem, neural network is used to identify the system. The response from modeling and designing cascade control system will be display with matlab simulation. The reason of using matlab simulation is because it can simulate dynamical system and it is a powerful tool for modeling and controller design. The result from simulation must be obtaining a good transient response of the system. A good transient response include low overshoot, fast rise time and loss oscillation. The system also necessary make the system insensitive to disturbance.

ABSTRAK

Projek ini adalah bertujuan untuk pengenalpastian gambarajah blok system kawalan motor arus terus dengan menggunakan *'neural network'*. Melalui projek ini, objektif utama yang akan dicapai ialah untuk kenalpasti keluaran kelajuaan dan arus untuk motor arus terus dengan menggunakan *'neural network'* Gambarajah blok sistem kawalan lata mengandungi motor arus terus, penukar arus terus kepada arus terus, pengawal arus dan pengawal kelajuan. *'PI controller'* digunakan untuk melaksanakan kawalan kelajuan. Tetapi jika menambah parameter *'PI controller'* kawalan proses masukan akan menjadi tidak stabil. Ia susah untuk mengawal parameter *'PI controller'* dengan cara manual. Untuk mengatasi masalah ini, *'neural network'* digunakan untuk mengenal pasti sistem kawalan tersebut. Hasil daripada rekaan sistem kawalan data boleh dilihat melalui simulasi *'matlab'*. Sebab utama mengunakan simlasi *'matlab'* ini adalah kerana boleh menghasilkan sistem yang dinamik dan ia merupakan sistem yang berkeupayaan tinggi untuk pemodelan dan reka bentuk kawalan. Keputusan yang dihasilkan daripada simulasi mestilah mempunyai sambutan fana yang baik. Sambutan fana yang baik adalah termasuk kurang terlajak, masa naik yang cepat dan kurang ayunan. Sistem ini juga seharusnya tidak sensitf pada gangguan.

TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE

LIST OF SYMBOLS

DC	-	Direct Current
PWM	-	Pulse Width Modulation
PI	-	Proportional Integral
PID	-	Proportional Integral Derivative
ANN	-	Artificial Neural Network
NN	-	Neural Network
MSE	-	Mean Squared Error

LIST OF APPENDIX

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

1.0 Background of Project

The aim of this project is to identification of cascade control separately-excited DC motor system by using an artificial neural network. A cascade control method of a DC drive consists of an inner current loop and outer speed loop. Such configuration gives advantages to the system where a limit can be applied to the armature current reference to protect the power converter from an armature over current. Another advantage of cascade control is the inner loop can be set up and tested first before the outer loop is engage [1]. Project phases are based on the modeling of DC motor, modeling of DC/DC converter and followed by the modeling of an overall cascade control system. Throughout this project, the response from modeling and designing cascade control DC Motor, DC/DC Converter will be display with matlab simulation. After simulate the response from cascade control DC motor, artificial neural network is use to compare the response of cascade control by using between the PI controller and by using artificial neural network. The reason of using this software is because it will be easily to simulate and check whether the modelings of the system are functional based on required.

1.1 Objective of Project

The objective of the project is to model a cascade control system consists of DC motor, DC-DC converter, current controller and speed controller in MATLAB/ SIMULINK platform.

Another objective is to identify the cascade control system by using the neural network.

Then, the objective of this project is to obtain good transient response of the system. Good transient responses include low overshoot, fast rise time, and loss oscillation.

Lastly, to make the system insensitive to disturbance. In this case disturbance might be an external load.

1.2 Scope of Project

The scopes of this project are:

- Artificial neural network is used to identify the cascade control separately-excited DC motor.
- A cascade control method of a DC drive consists of an inner current loop and outer speed loop
- Modeling of the cascade control of DC motor
- The response from modeling and designing cascade control will be displayed with matlab simulation

1.3 Problem Statement

Usually, the traditional PI (Proportional-Integral) controller can be used to improve the control performance successfully when position system of cascade control system is regarded as a linear system. However, in fact, the real system is nonlinear when saturation of the current and speed. Therefore, PI control method is not sufficient to deal with nonlinear situation. An alternative approach to traditional control methods, a neural network reference controller is proposed to establish an adaptive control system for the position of the cascade control system for the separately-excited DC motor to achieve the desired design conditions.

1.4 Expected Result

The expected results of this project are able to complete in development of simulation to achieve the objective of this project. This project is to perform a cascade control system using conventional PI controller. The overall cascade control system in this project is consists DC motor, H-bridge converter, current controller and speed controller.

The aim of this project is to perform identification of cascade control of separately-excited DC motor system using the artificial neural network. The overall in this project will simulate in matlab simulation. Throughout of this project, the response from the system must obtain a good transient response. A good transient response includes low overshoot, fast rise time and loss oscillation. This project also has to make the system insensitive to disturbance. In this case, disturbance might be an external load.

CHAPTER II

LITERATURE REVIEW

2.0 Overview

In this chapter, literature review of this project consists of characteristics of separately-excited DC motor, H-bridge converter, PI controller, artificial neural network and comparisons between simulation programs.

2.1 DC Motors

Electric motors are frequently used as the final control element in positional or speed-control system. Motor may be classified into two main categories DC motors and AC motors. Most motors used in modern control system are DC motors.

The advantages of DC motor:

- Ease of control
- Deliver high starting torque
- Near-linear performance

The disadvantages of DC motor:

- High maintenance
- Large and expensive (compared to induction motor)
- Not suitable for high-speed operation due to commutator and brushes
- Not suitable in explosive or very clean environment

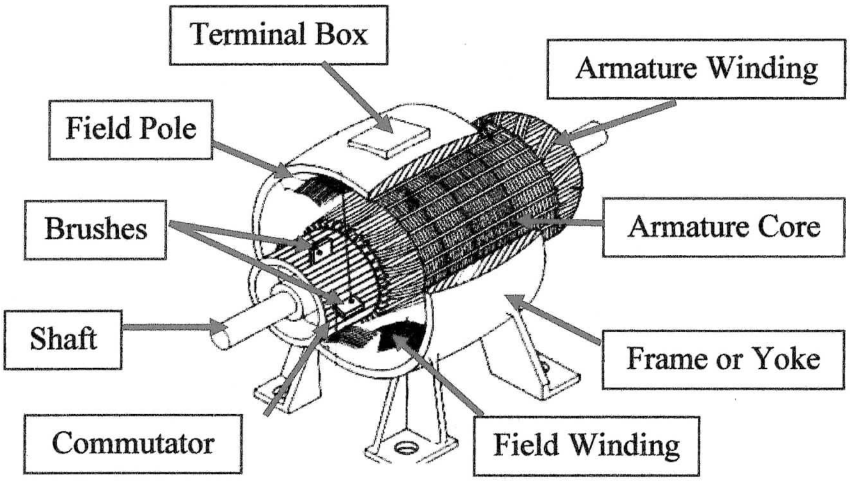

Figure 2.1: The Construction of DC Machine

Direct-current (DC) machines are driven from a DC power supply. DC machines are the most versatile of all rotating electrical machines. Their speed may be easily adjusted in very fine increments ranging from standstill to rated speed and even above. Figure 1.1 shows the construction of DC machines based on its part on the machine.

There are five types of DC motors:

- Separately-excited DC motors - It has a separate control of the armature and field currents.
- Shunt DC motors - The armature and field coils are in parallel. It provides lower starting torque.
- Series DC motors - The armature and field coils are in series. It has the highest starting torque. Compound DC motors: It has two field windings, one in series with the armature and one in parallel.
- Permanent magnet DC motors - This gives a constant value of flux density. The starting torque is proportional to the applied voltage and the torque decreases with increasing speed.

The DC motor has been the workhorse in industry for many reasons including good torque speed characteristics. It is a common actuator in control systems. It directly provides rotary motion and, coupled with wheels or drums and cables, can provide transitional motion. In this project, separately-excited is used.

2.1.1 Separately-Excited DC Motor

In many traction applications where both armature voltage and stator current are needed to control the speed and torque of the motor from "no load" to "full load", the separately excited DC motor is used for its high torque capability at low speed achieved by separately generating a high stator field current and enough armature voltage to produce the required rotor torque current. As torque decreases and speed increases, the stator field current requirement decreases and the armature voltage increases. Without a load (known as "zero torque speed"), the speed of the separately excited motor is strictly limited by the armature voltage and stator field current. Separately excited DC motors are the first type of motor to use closed-loop control and can also be used in servo systems for control of speed and / or position.

2.1.2 Operation

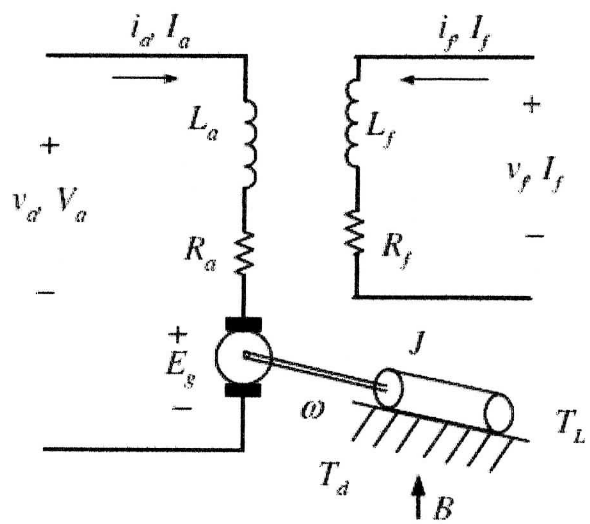

Figure 2.2: Separately-Excited Dc Motor

When a separately excited motor is excited by a field current of *if* and an armature current of *ia* flows in the circuit, the motor develops a back emf and a torque to balance the load torque at a particular speed. The *if* is independent of the *ia* .Each windings are supplied separately. Any change in the armature current has no effect on the field current. The *if* is normally much less than the *ia*.

2.1.3 Field and armature equations

- Instantaneous field current:

$$v_f = R_f i_f + L_f \frac{di_f}{dt} \tag{2.1}$$

where R_f and L_f are the field resistor and inductor, respectively

- Instantaneous armature current:

$$v_a = R_a i_a + L_a \frac{di_a}{dt} + e_g \tag{2.2}$$

where R_a and L_a are the field resistor and inductor, respectively

- The motor back emf, which is also known as speed voltage, is expressed as:

$$e_g = K_v \omega i_f \tag{2.3}$$

K_v is the motor speed (in rad/sec) and ω is the motor voltage constant (in V/A - rad/s)

2.1.4 Basic torque equation

- The torque develped by the motor is :

$$T_d = K_t i_f i_a \tag{2.4}$$

where ($K_t = K_v$) is the torque constant. (in V/A - rad/s)

- Sometimes it is written as :

$$T_d = K_t \phi i_a \tag{2.5}$$

For normal operation, the developed torque must be equal to the load torque plus the friction and inertia, i.e.:

$$T_d = J\frac{d\omega}{dt} + B\omega + T_L \tag{2.6}$$

Where:

B : viscous friction constant, (N.m/rad/s)

TL : load torque (N.m)

J : inertia of the motor (kg.m)

2.1.5 Steady-State Operation

Under steady - state operations, time derivatives is zero. Assuming the motor is not saturated.

- For field circuit

$$V_f = I_f R_f \tag{2.7}$$

- The back emf is given by :

$$E_g = K_v \omega I_f \tag{2.8}$$

- The armature circuit

$$V_a = I_a R_a + E_g = I_a R_a + K_v \omega I_f \tag{2.9}$$