SPEED CONTROL FOR DIRECT

CURENT (DC) MOTOR WITH

AN APPROACH OF FUZZY LOGIC

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7 MAY 2008

"I hereby declared that I have read through this report and found that it has comply
The partial fulfillment for awarding the degree of Bachelor of Electrical Engineering
(Industrial Power)"

Signature: …………………………………………..

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Date: 7 May 2008

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"I hereby declared that this report is a result of my own work except for the excepts that have been cited clearly in the references."

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ABSTRACT

This project approaches the fuzzy logic as a tool in controlling the speed of the motor. For acquire an accurate of fuzzy, Fuzzy Logic Toolbox 2.1 which is one of the applications in MATLAB software is used. Generally, in fuzzy logic system it is most important to define the range of input and output membership function in the fuzzy inference engine. Then, with the appropriate fuzzy rules, the accurate controlling system will be developed for the DC motor speed control. Fuzzy logic uses the whole interval of real numbers between zero (False) and one (True) to develop logic as a basis for rules of inference. Therefore, the speed of DC Motor that used Mamdani-style fuzzy inference system, which is composed of each one of input, and output variable.

ABSTRAK

Dalam projek ini, logik kabur digunakan sebagai alat untuk mengawal kelajuan motor. Perisian Fuzzy Logic Toolbox 2.1 adalah aplikasi dalam perisian MATLAB yang digunakan bagi mendapatkan ketepatan untuk logik kabur. Pada umumnya, dalam sistem logik kabur ini, yang paling utama adalah untuk menetapkan linkungan untuk masukan dan keluaran fungsi keahlian dalam enjin kesimpulan logik kabur. Kemudiannya, dengan peraturan yang sesuai, sistem kawalan yang tepat boleh dibina untuk mengawal kelajuan motor arus terus. Logik kabur ini mengunakan seluruh lingkungan nombor nyata antara sifar (Salah) dan satu (Betul) untuk membangunkan logik sebagai peraturan bagi kesimpulan. Oleh itu, kelajuan motor arus terus yang mengunakan cara Mamdani enjin kesimpulan logic kabur, yang menghasilkan setiap pemalar masukan dan keluaran.

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CHAPTER 1

INTRODUCTION

1.1   Introduction

The speed control is one of important component in Direct Current motor (DC motor) operation. In controlling the speed of a DC motor, some improvement needs to be done toward speed regulation during transient loading conditions. The control includes a regulating circuit that having an output for controlling the armature voltage to the motor. An input speed reference signal corresponding to the desired speed is provided to the regulating circuit. A feedback signal proportional to armature voltage is also provided to the regulating circuit to establish an error signal for operating the control to regulate the voltage to the motor and therefore the motor speed.

This project approaches the fuzzy logic as a tool in controlling the speed of the motor. Fuzzy logic is based on the theory of fuzzy sets, where an objects membership of a set is gradual rather than just member or not. Fuzzy logic uses the whole interval of real numbers between zero (False) and one (True) to develop logic as a basis for rules of inference. Particularly, the fuzzified version of the modus ponens rule of inference enables computers to make decisions using fuzzy reasoning rather than exact. The employment of fuzzy control is commendable for very complex processes, when there is no simple mathematical model and for highly nonlinear processes. Then, if the processing of linguistically formulated expert knowledge is to be performed the fuzzy control can be employed.

For acquire an accurate of fuzzy, Fuzzy Logic Toolbox 2.1 which is one of the applications in MATLAB software is used. Generally, in fuzzy logic system it is most important to define the range of input and output membership function in the fuzzy inference engine. Then, with the appropriate fuzzy rules, the accurate controlling system will be developed for the DC motor speed control. Therefore, the speed of DC Motor that used Mamdani-style fuzzy inference system, which is composed of each one of input, and of output variable.

1.2   Problem Statement

The PI and PID controller have been used as control method of servo driving in industrial control field. The driving specific property can be indicated well, a control constant is a property set. But the property constant need to be changed in order to maintain the optimum driving state if the driving point or the motor parameters are changed. Recently the fuzzy controller has appeared which is based on knowledge or an experience of expert rather than on a complicate mathematical modeling. The fuzzy controller works well using experimental information even if not having mathematical modeling. Moreover, the fuzzy controller is capable of real time control using fuzzy rule base.

1.3   Project Objective

The objective of the project is to build simulation system and analysis for controlling the speed of DC motor using fuzzy logic linguistic analysis. The Madani-style is one of the fuzzy inference systems. The system is operated by several rules that state in the system which show the controlling the DC motor.

1.4   Project Scope

1.4.1   To simulate the speed control DC Motor within the value that needed using fuzzy logic operation.

1.4.2   To analysis the speed control DC Motor that had been set is varying within the value that needed.

1.5   Report Outline

This report contains of 7 chapters. Chapter 1 covers an introduction, an objective about the project and the problem statement of this project. Second chapter provides a literature review of this project which review some related work that had been done by other people.

The main part for this project explains in Chapter 4. This chapter describes the research and identify on DC motor and Fuzzy Logic, learning and developing project using Fuzzy Logic Toolbox 2.1, analysis the overall design system and, the final adjustment for the design to get the good performance system.

The further project development process is discussed in Chapter 5. The next chapter elaborates and comments on the result of the simulation. The final chapter is come conclusion for the whole project

CHAPTER 2

LITERATURE REVIEW

Literature review was an activity for researcher to research about project or paper work that have been done by some one else. The research must be done in their scope of project, which means the research must be related to the projects that have been suggested. Paper work or journal that related with DC motor speed control should be take, as it can help in the future if problem occur. Beside that, it also helps in collecting theory background because journal or paper work is new from the theories that get from book.

In other word literature review has been done to make sure;

    i.   It can give reader the overview of the project that has been suggested from the project that already been done by someone else.

    ii.   The research will highlight the advantage or disadvantage of the project before.

    iii.   The process or methodology that has been use for the project before can be implementing to the project that have been suggested.

    iv.   The information that not in the project before can be adds to make the project better.

2.1   Introduction of DC Motor Speed Control

There are two common methods in use. The common ways in which the speed of DC machine can be controlled are by adjusting the field resistance, R_f and adjusting the terminal voltage applied to the armature.

Reel drives require this kind of control. The dc motor's material is wound on a reel at constant linear speed and constant strip tension, regardless of diameter. In controlling the field resistances, the control is obtained by weakening the shunt-field current of the dc motor to increase speed and to reduce output torque for a given armature current. Since the rating of a dc motor is determined by heating, the maximum permissible armature current is approximately constant over the speed range. This means that at rated current, the dc motor's output torque varies inversely with speed, and the dc motor has constant-horsepower capability over its speed range.

DC motors offer a solution, which is good for only obtaining speeds greater than the base speed. A momentary speed reduction below the dc motor's base speed can be obtained by overexciting the field, but prolonged overexcitation overheats the dc motor. Also, magnetic saturation in the dc motor permits only a small reduction in speed for a substantial increase in field voltage.

DC motors have a maximum standard speed range by field control is 3:1, and this occurs only at low base speeds. Special dc motors have greater speed ranges, but if the dc motor's speed range is much greater than 3:1, some other control method is used for at least part of the range.

In armature-voltage DC motor speed control method, shunt-field current is maintained constant from a separate source while the voltage applied to the armature is varied. Dc motors feature a speed, which is proportional to the counter emf. This is equal to the applied voltage minus the armature circuit IR drop. At rated current, the torque remains constant regardless of the dc motor speed (since the magnetic flux is constant) and, therefore, the dc motor has constant torque capability over its speed range.

2.1.1 Changing the Field Resistance

In understanding the effect when the field resistor of a DC motor is changed, assume that the field resistor increase and observe the response. When the field resistance is increased, the field current will be decreased [6].

$$I_{f=}\frac{V_t}{R_f} \tag{2.1}$$

As the field current is decreased, the flux, Φ decreased with it. A decreased in flux caused an instantaneous decreased in the internal generated voltage, E_A.

$$E_A = Kf \tag{2.2}$$

This caused a large increased in the machine's armature current, I_A.

$$I_A = \frac{(V_t - E_A)}{R_A} \tag{2.3}$$

The induced torque in a motor is given

$$t_{ind} = Kf I_A \tag{2.4}$$

Since the flux in the machine is decreased while the current I_A is increased, this does induce the torque, τ change. Since the $t_{ind} > t_{load}$, the motor speed will be increase.

However, as the motor speed up, the internal voltage, E_A will rises, causing I_A to fall. As I_A falls, the induced torque t_{ind} falls too, and finally the t_{ind} again equal to τ_{load} at a higher steady-state speed than originally.
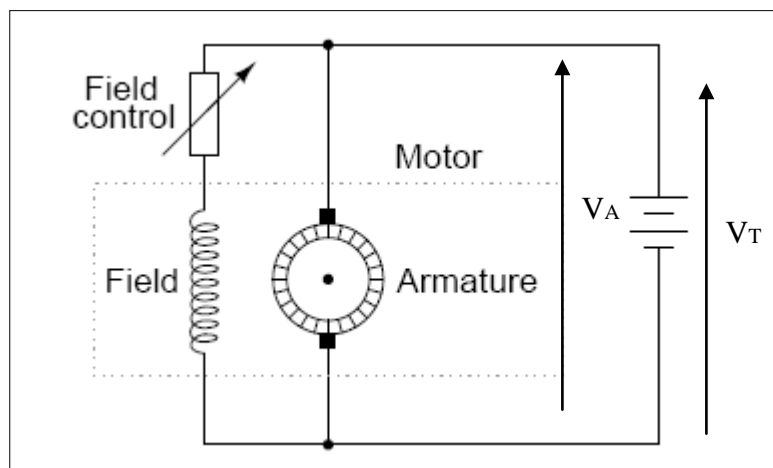

Figure 2.1: DC Motor equivalent circuit

(Source: http://homepages.which.net/~paul.hills/SpeedControl/SpeedControllersBody)

2.1.2   Changing the Armature Voltage

The second method in controlling the DC motor speed control involved the changing the voltage applied to the armature of the motor without changing the voltage applied to the field. A connection similar to Figure 1 is necessary for this type of control. In effect, the motor should be separately excited to use armature voltage control.

When the voltage V_A is increased, then the armature current, I_A in the motor must rise. This situation based on Equation 2.3. As I_A is increased, the induced torque, t_{ind} also increased and making $t_{ind} > t_{load}$ and the speed, ω of the motor to increased.

But, as the speed increased, the internal generated voltage E_A is increased and causes the armature current to decrease. This situation will decreased the torque induced, causing to t_{ind} equal to t_{load} at a higher rotational speed, ω.

2.1.3   Speed Controller

The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. The controller may or may not actually measure the speed of the motor. If that does, this is called a Feedback Speed Controller or Closed Loop Speed Controller, if not this controller is called an Open Loop Speed Controller. Feedback speed control is better, but more complicated, and may not be required for a simple robot design.

Motors come in a variety of forms, and the speed controller's motor drive output will be different dependent on these forms. The speed controller presented here is designed to drive a simple cheap starter motor from a car, which can be purchased from any scrap yard. These motors are generally series wound, which means to reverse the motor, they must be altered slightly.
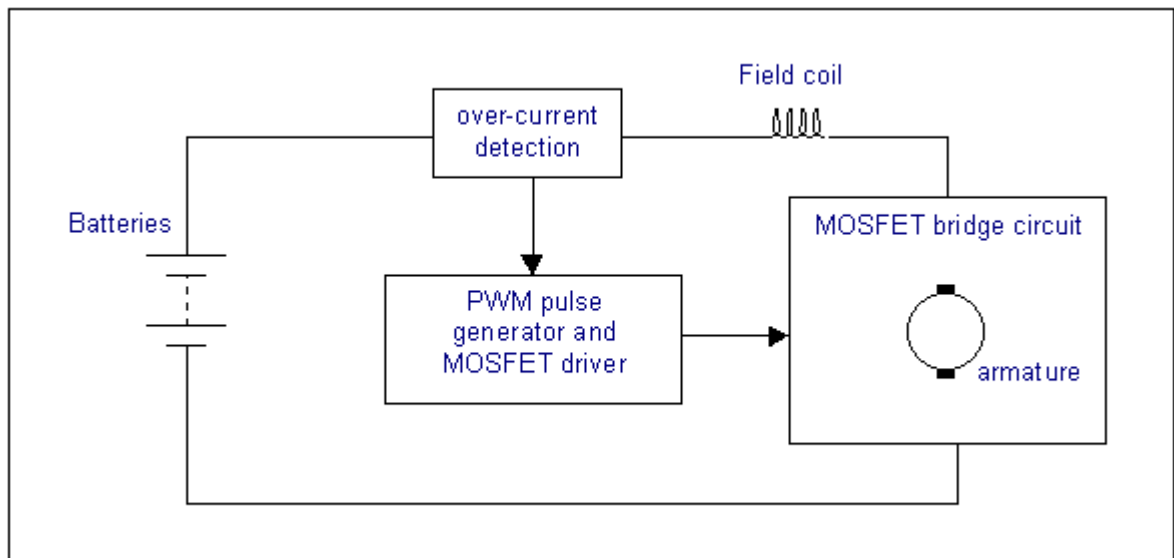
Figure 2.2: A simple block diagram of the speed controller

(Source: http://homepages.which.net/~paul.hills/SpeedControl/SpeedControllersBody)

The speed of a DC motor is directly proportional to the supply voltage. The speed controller works by varying the average voltage sent to the motor. This can be done by simply adjusting the voltage sent to the motor, but this is quite inefficient to do. A better way is to switch the motor supply on and off very quickly. If the switching is fast enough, the motor does not notice it, this only notices the average effect.

When a film is shown in the cinema, or the television, the actually that showed is a series of fixed pictures, which change rapidly enough that eyes just see the average effect - movement. The brain fills in the gaps to give an average effect.

Now imagine a light bulb with a switch. When the switch is closed, the bulb goes on and is at full brightness, says 100 Watts and when the switch is closed is 0 Watts. Now if the switch is closed in a fraction of a second and then opens for the same amount of time, the filament would not have time to cool down and heat up. This will just get an average glow of 50 Watts. This is how lamp dimmers work, and the same principle is used by speed controllers to drive a motor. When the switch is closed, the motor sees 12 Volts, and when the switch is open it sees 0 Volts. If the switch is open for the same amount of time as it is closed, the motor will see an average of 6 Volts, and will run more slowly accordingly. As the amount of time that the voltage is *on* increases compared with the amount of time that it is *off*, the average speed of the motor increases.

The time that takes a motor to speed up and slow down under switching conditions is dependant on the inertia of the rotor (basically how heavy the motor), and how much friction and load torque there is.
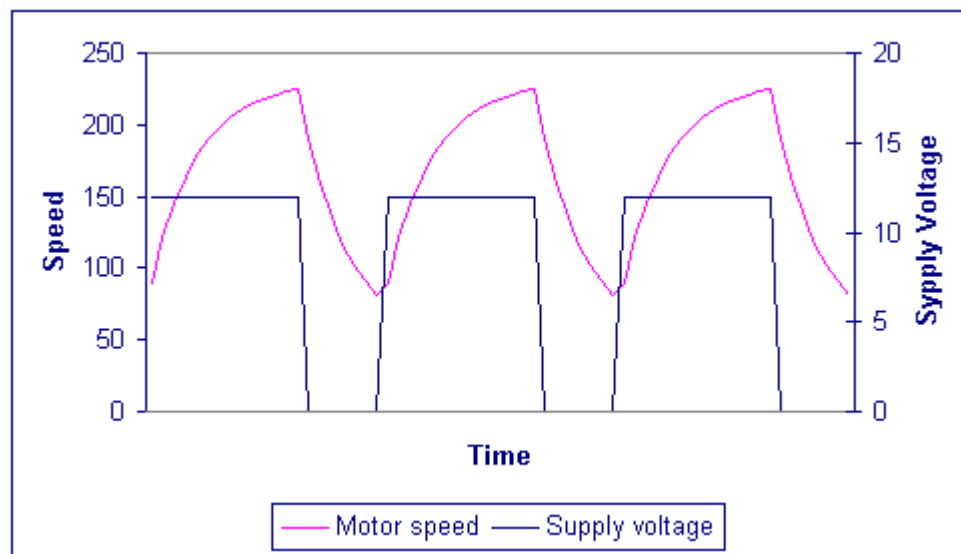

Figure 2.3: The graph of the speed of a motor that being turned on and off fairly
(Source: http://homepages.which.net/~paul.hills/SpeedControl/SpeedControllersBody)

From the graph, the average speed is around 150, although it varies quite a bit. If the supply voltage is switched fast enough, where no time to change speed much and the speed will be quite steady. This is the principle of switch mode speed control. Thus the speed is set by Pulse Width Modulation (PWM).

2.2   Introduction of Fuzzy Logic

The Fuzzy Logic was invented in 1965 by Professor Lotfi A. Zadeh of the University of California. Fuzzy logic is used around the world in many application areas such as control, instrumentation, laboratory automation, factory automation, system identification, system modeling and much more.

2.2.1   The Fuzzy Theory

The adjective "fuzzy" means boundaries are vague like on feather. Probability is the only acknowledgement theory of the theories, which are studying ambiguities. Both probability and the fuzzy theory are theories which can be used to deal with ambiguity. Fuzzy theory can be used for a numerical analysis of ambiguity.