FUZZY LOGIC CONTROLLER FOR DIRECT CURRENT (DC) MOTOR DRIVE

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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 (Power Electronic and Drive)"

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Date : MAY 2008

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

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

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For my beloved father and mother
Razali bin Ibrahim and Normah binti Muda
In appreciation of supports and understanding

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ABSTRACT

Fuzzy logic controller is one type of intelligent controller. Fuzzy logic is much just like human operator or closer in spirit to human thinking and natural language than the traditional (classical) logical system. Basically, fuzzy logic have an effective means for describing the approximate, inexact natural or ambiguous of the reality problem. The fuzzy logic controller is useful for control processes that too complex to analyze by conventional quantitative techniques. This thesis is concern with fuzzy logic controller for DC Motor Drive. The first stages of this project are to study in detail the capability and ability of fuzzy logic compare to other controller that use in non-linear system like DC Motor Drive. The second stage is to design the fuzzy logic controller using the Fuzzy Logic Toolbox software in MATLAB. Lastly, designs the system apply the fuzzy logic controller in this system. The simulation work is done using a MATLAB/SIMULINK platform.

ABSTRAK

Pengawal fuzzy Logik adalah sejenis pengawal yang pintar. Fuzzy Logik menyerupai pertuturan manusia atau menghampiri pemikiran manusia dalam bahasa pertuturan berbanding dengan klasik logik sistem. Secara umumnya, fuzzy logic mempunyai keupayaan untuk menghurai segala penghampiran, ketidaktepatan dan keserabutan dalam segala masalah yang timbul. Pengawal Fuzzy logic sangat berguna untuk mengawal sesuatu proses yang kompleks untuk dianalisis melalui teknik-teknik yang biasa. Tesis ini akan memberi fokus tentang Pengawal Fuzzy Logik untuk pemacu motor arus terus (AT). Peringkat pertama projek ini adalah untuk mengkaji segala kebaikan dan keupayaan Fuzzy Logik berbanding pengawal yang lain dalam mengawal system tidak linear seperti pemacu motor arus terus (AT). Peringkat kedua pula adalah merekabentuk pengawal Fuzzy Logik menggunakan "Fuzzy Logic Toolbox" yang terdapat dalam MATLAB. Akhir sekali, merekabentuk satu sistem dan mengaplikasikan Pengawal Fuzzy Logik ini ke dalam sistem tersebut. Segala kerja simulasi dilakukan menggunakan MATLAB/SIMULINK

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LIST OF ABBREVIATIONS

MISO	-	Multiple Input Single Outputs
FLC	-	Fuzzy Logic Controller
SISO	-	Single Input Single Output
PID	-	Proportional Integral Derivation
LMI	-	Linear Matrix Inequality

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CHAPTER I

INTRODUCTION

1.1 Project Overview

Direct current (DC) motors have variable characteristics and are used extensively in variable-speed drives. DC motor can provide a high starting torque and it is also possible to obtain speed control over wide range. To achieve that, the implementation of speed controller is a must. It is important to use an intelligent controller to control DC motor in desired speed. For this project, the implementation of fuzzy logic controller in DC motor drive is the main objective.

Fuzzy logic controller is equivalent to have computers reason like humans do, just much faster. Normally when thinking of computer making decisions, the output would be true or false. However, fuzzy logic is a way of letting the computer say little, big, bigger, not so big, and so forth, and have an output decided upon from these vague inputs.

Fuzzy logic has some strength over conventional control algorithms like for example Proportional-Integral (PI) control. Often biological systems are nonlinear, difficult, or impossible to model mathematically. However, fuzzy logic is empirically-

based and model free, thus opens doors for control systems that would normally be deemed unfeasible for automation. Furthermore, fuzzy logic is very robust and does not need precise and noise-free inputs to generate usable outputs. Finally, it can easily be modified and fine tuned during operation.

DC motor plays a significant role in modern industrial. These are several types of applications where the load on the DC motor varies over a speed range. These applications may demand high-speed control accuracy and good dynamic responses.

In home appliances, washers, dryers and compressors are good examples. In automotive, fuel pump control, electronic steering control, engine control and electric vehicle control are good examples of these. In aerospace, there are a number of applications, like centrifuges, pumps, robotic arm controls, gyroscope controls and so on.

1.2 Objectives

The main core of this project is to design a fuzzy logic speed control system of DC Motor drive. This system will be able to control the DC motor speed at desired speed regardless the changes of load. The specific objective can be described as below:

- To design a fuzzy logic controller
- To develop a Simulation model for fuzzy logic controller and DC motor drive
- To compare the performance of fuzzy logic controller with PI controller towards the operation of DC motor.

1.3 Problem Statement

There are many types of controller that use to improve the capability and stability of the DC motor drive. Fuzzy logic is an intelligent controller that can control system especially for non-linear system better than other controller because of its simplicity and reduced development cycle. Yet, the implementation of this method of control is less. Fuzzy logic controller is ease in implementation and can provide more "user-friendly" environment and also can achieve greater performances.

1.4 Scope of the project

The main areas are being identified those needs to be worked out are:

1. To study the theory of fuzzy logic controller
2. To study the capability of the controller in non-linear systems
3. To design the fuzzy logic controller for dc motor drive

1.5 Project Methodology

In order to achieve the goal of this project, the understanding of conceptual of fuzzy logic controller must be done at the first place. The theories that include in the research will focus more on the fuzzy logic theoretical such as fuzzy set, fuzzy set operation, fuzzy logic components and etc. Fuzzy logic components include fuzzification, inference engine, knowledge based and defuzzification. Furthermore, the capability and the ability of fuzzy logic controller in control non linear system will be study in detail.

After all theories have been studied, then the designation phase begins. The first one is, the designation of Fuzzy Logic controller with its membership function and rule based. For this task, the FIS editor in Matlab 7 was used. Then, continue with the mathematical modeling for dc motor drive. Based on the pre-designed fuzzy logic controller and mathematical model of dc motor drive, the design phase simulation model begins. All of simulation model will be done using Matlab 7 Simulink program. In this program, all the designs were represented in block diagram which is simpler than construct them in schematic diagram.

After all simulation has been done, the performance of dc motor drive with fuzzy logic controller is recorded. This data will be compare to other controller performance in obtaining the robustness of dc motor drive. For this project, the controllers used in comparison are fuzzy logic and PI only.

1.6 Thesis Structure

This thesis consists of five chapters that will explain and discuss more details about this project. The first chapter will describe about the project overview which are the project background, objectives, problem statements, scopes and research methodology.

The second chapter is the literature review about various systems that use fuzzy logic as the controller. From this literature review, the research about the fuzzy logic controller that applies for various systems can be learnt especially the performance and effectiveness of fuzzy logic. Furthermore, the theory of fuzzy logic controller will discuss too for example, the fuzzy set operation, the component on fuzzy logic and etc.

The third chapter is about the design of DC motor drive and fuzzy logic controller. This chapter will explain more on designing dc motor drive using mathematical calculation and also by using Matlab 7 Simulink program. The fuzzy logic controller is design using Matlab 7 FIS editor. The detail of membership function for each and every input and output will be given. Then, the detail of rules used in fuzzy mamdani model will be shown and represented in table.

The forth chapter is all about result of fuzzy logic controller and dc motor drive simulation models. The result will be compare to PI controller in terms of speed error and transient response.

The fifth chapter is about the implementation of fuzzy logic controller in hardware. The design of schematic diagram will be given also with explanation of every electronic component used in that project.

The sixth chapter which is also the last chapter is regarding the recommendation and the conclusion of the project. The recommendation suggested is purposed with the intention of improving the project in future.

CHAPTER II

FUZZY LOGIC CONTROLLER

2.1 Introduction

This chapter will discuss the literature review according the fuzzy logic controller, basic concept of fuzzy logic controller (FLC) including the theory and definition of fuzzy set, membership function, and the concept of fuzzy control system. In addition, in this chapter will discuss to about the procedure and methodology for designing fuzzy logic controller.

2.2 Literature review

Fuzzy Control of Mechanical Vibrating System. Fuzzy logic is used to control active hydropneumatic suspension. The ability of fuzzy logic were discuss that can improve the reduction of the body acceleration caused by the car body when road disturbance from uneven surface, pavement point and etc which is act the tires of running the cars. The fuzzy controller used in this designing has three inputs which are body acceleration, body velocity and body deflection velocity and one output is desired actuator force. The simulation result is to compare the active and passive suspension system. In the end of this research are the active suspension system is proposed to achieve both ride comfort and god handling. The aim was achieve by simulation result that the active suspension system based on fuzzy logic controller shows the improved stability of the one-quarter-car model.

Robust Speed Fuzzy Logic Controller for DC Drive were discuss the robust fuzzy speed control for a DC drive is considered. The basis of the heuristic reasoning the main features of the robust speed controller are supposed and the fuzzy logic controller that can control the DC drive was designed. The comparison between PI controller and Fuzzy Logic Controller to control the DC Drive were approved. In the end of this paper, the robust fuzzy speed control for a DC Drive was examined. The fuzzy logic controller is able to overcome the disadvantage of usual PI-controller in sensitiveness to inertia vibration and sensitiveness to variation of the range of reference speed alteration.

Reliable LQ Fuzzy Control for Continuous Time Non Linear Systems with Actuators Fault using multiple Lyapunov functions, an improved linear matrix inequality (LMI) method for the design f LQ fuzzy controllers is investigated, which reduces the conservation of using a single Lyapunov function. A suboptimal reliable LQ fuzzy controller is given by means of an LMU optimization procedure, which can not guarantee the stability of the closed lop overall fuzzy system for all cases. Finally, a numerical simulation on the chaotic Lorenz system is given to illustrate the application of the proposed design method.

Fuzzy Logic Controller for an Inverted Pendulum System was discussed about the designing fuzzy logic controller for Inverted Pendulum System. The case of fuzzy logic for the derivation of a practical control scheme for stabilizing the inverted pendulum was presented in this paper. The fuzzy logic controller required only sensing the pole angular and cart position, and the implementation is simple. In addition, the comparison of fuzzy logic controller and conventional controller (PID) were discussed too. In the end of this paper, the fuzzy logic controller is ease for implementation of this type of system and can give a best performance compare the conventional controller (PID).