SPEED CONTROL OF BUCK-CONVERTER DRIVEN DC MOTOR USING PD-TYPE FUZZY LOGIC CONTROLLER

ZAKARIA BIN ABDUL RAHMAN

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Electronics)

Faculty of Electrical & Electronics Engineering
UNIVERSITI MALAYSIA PAHANG

MAY 2009

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

Signature : _____

Name : MOHD ASHRAF BIN AHMAD

Date : 08 MAY 2009

"All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly; otherwise the information presented in this report is solely work of the author."

Signature : _____

Author : ZAKARIA BIN ABDUL RAHMAN

Date : 06 MAY 2009

To my beloved mother and father

Mr. Abdul Rahman Bin Mohd

Mrs. Minah Binti Ismail

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main project supervisor, Mr Mohd Ashraf Bin Ahmad, for encouragement, guidance, critics and friendship. I am also very thankful to my lecturers Mr Reza Ezuan Bin Samin and for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to Universiti Malaysia Pahang (UMP) for funding my Bachelor study. Librarians at UMP, and University Technology Malaysia and also deserve special thanks for their assistance in supplying the relevant literatures. My fellow final year students should also be recognized for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. I am grateful to all my family members.

ABSTRACT

The purpose of this project is to control speed of buck converter driven DC motor using PD-type fuzzy logic controller. At the beginning, the simulation (MATLAB simulink) is started with buck converter driven DC motor modeling. In this project, PD-type fuzzy logic controller is designed based on the membership function and the rule base. Thus, the designed PD-type fuzzy logic is applied to the buck converter driven DC motor model. The objective of the simulation is to predict the system response of the buck converter driven DC motor with different membership function. For the first model of PD-type fuzzy logic controller, it will use 3 membership functions which are equal to 9 rule base. Then for the second simulation, it will use 5 membership functions which are equal to 25 rule base and the last model of controller use 7 membership function that are equal to 49 rules. Fuzzy logic controller that is capable of improving its performance in the control of a nonlinear system whose dynamics is unknown or uncertain. This direct learning fuzzy controller is able to improve its performance without having to identify a model of the plant.

ABSTRAK

Tujuan projek ini dibuat untuk mengawal kelajuan penukar turun pemacu DC motor dengan mengunakan kawalan jenis *PD- fuzzy logic.* Pada peringkat permulaan, model penukar turun pemacu DC motor direka dan disimulasi dengan menggunakan simulasi MATLAB. Dalam projek ini, kawalan jenis *PD-fuzzy logic* direka berdasarkan kepada fungsi keahlian (*membership function*) dan peraturan. (*rule*). Oleh yang demikian, kawalan jenis *PD-fuzzy logic* yg telah direka diaplikasikan kepada model penukar turun pemacu DC motor melalui simulasi MATLAB. Tujuan simulasi dijalankan ialah untuk meramal tindak balas terhadap sistem penukar turun DC motor menggunakan fungsi keahlian yang berbeza.Untuk model yang pertama kawalan jenis *PD-fuzzy logi,* ia menggunakan 3 fungsi keahlian yang mana bersamaan dengan 9 peraturan. Kemudian, untuk simulasi yang kedua, ia akan meggunakan 5 fungsi keahlian yang mana bersamaan dengan 25 peraturan dan model kawalan terakhir meggunakan 7 fungsi keahlian yang bersaman dengan 49 peraturan. Kawalan *fuzzy logic* berpotensi membaiki persembahan di dalam system tidak linear yang mana dinamiknya tidak diketahui atau tidak pasti. Pelajaran terus kawalan jenis *PD-fuzzy logic* mampu membaiki persembahan tanpa perlu mengenal pasti model loji.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Ue	-	Input voltage
Ua	-	Output voltage
δ	-	Duty ratio
iL	-	Inductance current
ΔiL	-	Current ripple
L	-	Inductance
R	-	Resistance
C	-	Capacitance
uC	-	Capacitor voltage
iL	-	Coil current
iA	-	Output current
LM	-	Motor inductance
ωKE	-	Electromagnetic voltage source
j	-	Moment of inertia of the motor
KM	-	Motor back emf constant
Ts	-	Settling time
Tr	-	Rise time
$\%OS$	-	Percent overshoot
Tp		Peak time

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Background

Control System Design and Analysis Technologies are widely suppress and very useful to be applied in real-time development. Some can be solved by hardware technology and by the advance used of software, control system are analyzed easily and detail. There are many techniques to control the speed of the DC motor such as stator voltage control and current injected control. For achieving variable speed operation, the frequency control method of the DC motor is the best method among all the methods of the speed control. Vector control of the dc motor is considered fast response and high performance method to achieve variable speeds using variable frequency source. In the last decade many closed loop speed control techniques have been developed to provide good performance. However, the desired drive specification still can not be perfectly satisfied and their algorithms are too complex.

Recently the fuzzy logic approach has been objected of an increasing interest and has found application in many domains of control problem. The main advantage of fuzzy logic control method as compared to conventional control techniques resides in fact that no mathematical modeling is required for controller design and also it does not suffer from the stability problem. In motion control, fuzzy logic can be considered as an alternative approach to conventional feedback control. It has been recently demonstrated that dynamic performance of electric drives as well as robustness with regards to parameter variations can be improved by adapting the non linear speed control

techniques. Fuzzy logic is a non linear control and it allows the design of optimized non linear controllers to improve the dynamic performance of the conventional regulators. Fuzzy logic speed control is considered for the design of the speed controller. The control performance of this controller is evaluated by simulation and implementation at different operating conditions.

Simulation can be very helpful in gaining insights to the dynamic behavior and interactions that are often not readily apparent from reading theory. Next to having an actual system to experiment on, simulation is often chosen by engineers to study transient and control performance or to test conceptual designs. MATLAB/SIMULINK is used because of the short learning curve that most students require to start using it, its wide distribution, and its general-purpose nature. This will demonstrate the advantages of using MATLAB for analyzing power system steady state behavior and its capabilities for simulating transients in power systems and power electronics, including control system dynamic behavior.

1.2 Objectives

The objectives of this project are:-

i. To control buck converter driven DC motor speed by using PD-type fuzzy logic controller in MATLAB simulink.

ii. To analyze the performance of buck converter driven DC motor speed control using PD-type fuzzy logic controller.

1.3 Scope of Project

This project is to design a PD-type fuzzy logic controller that can be use to control of buck converter driven dc motor speed. As a machine performance is a vital factor for a big production line, this project will examine the efficiency and performance of a buck converter driven DC motor with implementation of control strategy. Thus, the focuses of this project are stated below:-

(i) Model of buck converter driven DC motor in state space.

(ii) Develop controller PD-type fuzzy logic controller.

(a) 3 membership function (rules 9)

(b) 5 membership function (rules 25)

(c) 7 membership function (rules 49)

(iii) Analyze on performance comparison.

i. Settling time, Ts 2% of its final value.
ii. Rise time, Tr 10%-90% of its final value.
iii. Percent overshoot, %OS
iv. Peak time, Tp

1.4 Thesis Outline

This thesis consists of five chapters. For chapter I, it will discuss about the introduction of the project which is includes background, objectives, scopes and also problem statement.

Then for the chapter II, it will provides a literature review of Fuzzy Logic controller and discusses the project that has been done before by using Fuzzy Logic controller and Buck Converter driven DC motor.

For the chapter III it will cover on the methods that are used including flow chart and phase during finishing this project.

Chapter IV focus on the result obtained from the simulation of 3 difference membership functions and chapter V cover the conclusion, recommendations for this project.

CHAPTER II

LITERATURE REVIEW

2.1 Speed Control of a DC Motor using Fuzzy Logic

The speed of DC motors can be adjusted within wide boundaries so that this provides easy controllability and high performance. DC motors used in many applications such as still rolling mills, electric trains, electric vehicles, electric cranes and robotic manipulators require speed controllers to perform their tasks. Speed controller of DC motors is carried out by means of voltage control in 1981 firstly by Ward Leonard [1]. The regulated voltage sources used for DC motor speed control have gained more importance after the introduction of thyristor as switching devices in power electronics. Then semiconductor components such as MOSFET, IGBT and GTO have been used as electric switching devices [2].

In general, the control of systems is difficult and mathematically tedious due to their high nonlinearity properties. To overcome this difficulty, Fuzzy Logic Controller can be developed. The best applications of Fuzzy Logic Controller are the time variant systems that are nonlinear and ill-defined**.** One of the most important Fuzzy Logic Controller applications in real life is the metro system in the city Sendia of Japan in 1987**.** Nowadays, Fuzzy Logic Controller applications are successfully used in many fields including automatic focus cameras, household materials such as dishwashers and also in automobile industry.

The speed response of a DC motor exposed to fixed armature voltage was investigated for both under loaded and unloaded operating conditions. The first, the DC motor was operated for a required reference speed under loaded and unloaded operating conditions using PI control method. Then, to make performance comparison, the speed of the system was controlled using Fuzzy Logic Controller. The Fuzzy Logic Controller system designed for operating at fixed speed under different load conditions are simulated at MATLAB/Simulink environment. In this study, chopper circuit was act as a motor driver.

2.2 DC motor velocity control through a DC-to-DC power converter

DC Machines are extensively used in many industrial applications such as servo control and traction tasks due to their effectiveness, robustness and the traditional relative ease in the devising of appropriate feedback control schemes [3]. The increasing availability of feedback controller design techniques and the rapid development of circuit simulations programs, such as Pspice, offer much wider possibilities to analyze and redesign, currently used DC motor drive systems

Customarily, the proposed feedback controllers use step, ramp and constant functions as reference trajectories for the specification of the desired angular velocity profile.

Conventionally, DC motor drives have widely employed thyristor-based phase controlled rectifiers which supply adjustable terminal voltage for speed control [4]. We note that DC/DC converters can be operated at much higher switching frequencies

(above 50 KHz) and may be designed to supply continuous armature current under all load conditions.

Following to the J. Linares-Flores and H. Sira-Ramírez, they propose a smooth “starter" for the velocity regulation of a DC motor machine. By using a DC-to-DC power converter of the “buck" type as an “electronic starter" for the machine operation initiated at rest conditions towards a desired final constant reference angular velocity. Since the controller only uses a smooth reference trajectory input for the converter input current, the proposed scheme results in a “sensorless" feedback controller. The starter control input is designed so that a smooth trajectory is followed by the motor angular velocity.

2.3 Speed Regulation of DC Motors Using Intelligent Controllers

Due to its excellent speed control characteristics, the DC motor has been widely used in industry even though its maintenance costs are higher than the induction motor [6]. As a result, speed control of DC motor has attracted considerable research and several methods have evolved. Proportional-integral (Pi) controllers have been widely use for speed control of DC motor. In order to reduce the loading effect and minimize time delay feed forward controller added to the PID controller.

In addition application of several new methods in order to control the speed regulation of DC motors are designed. These methods are includes Fuzzy auto tuning, Gas-based PID controller, Gas-Based Fuzzy PID Controller, Fuzzy PID Controller using neural network and Brain Emotional Learning Based Intelligent Controller (BELBIC).

All the Control strategies utilize the output speed error and its derivative as feedback damping signals.

The process of estimating parameter value by neural networks is usually referred to as system identification. It is often assumed that the model has a specific mathematical model with a set of unknown parameters. Neural networks are often used to find appropriate parameter values. Simulation results of the corresponding system are obtained and compared.

CHAPTER III

METHODOLOGY

3.1 Introduction

In developing a project, methodology is one of the most important elements to be considered to make sure that the development of the project is smooth and to get the expected result successfully. A good methodology can described the structure or the flow of the project where by it can be the guideline in managing it. It is also to avoid the project to alter course from the objectives that have been stated or in other words the project follow the guideline based on the objectives. Figure 3.1 shows the flow chart of methodology of this project which includes:-

Phase I : Project preview

Phase II : Development dynamic model of buck converter DC motor

Phase III : MATLAB simulation

Phase IV : Analysis the result from the MATLAB.