SUPERVISOR ENDORSEMENT

"I hereby declared that I have read through this report entitle "Speed Control of Permanent Magnet Synchronous Motor Drive Using Fuzzy Logic Controller" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)."

Signature : ……

Supervisor Name : Associates Professor Dr. Zulkifilie Bin Ibrahim

Date : ……

SPEED CONTROL OF PERMANENT MAGNET SYNCHRONOUS MOTOR DRIVE USING FUZZY LOGIC CONTROLLER

CHANG TING WEI

A report submitted in partial fulfillment of the requirements for the degree of Bachelor in Electrical Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I declared that this report entitle “Speed Control of Permanent Magnet Synchronous Motor Drive Using Fuzzy Logic Controller” 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 other degree.

Signature : ……

Name : Chang Ting Wei

Date : ……

DEDICATION

To my beloved father, mother, my brothers and family

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ABSTRACT

The aim of this project is to utilize the fuzzy logic controller (FLC) in controlling the speed of a sinusoidal permanent magnet synchronous motor (PMSM) drive. The fixed controlled parameter of SPMSM drive with fuzzy logic control are studied during the nominal phase and load disturbance phase and will be compared with the reference parameters to see the degrade of the speed performance. Besides, the study of re-tuning of membership function for difference speed command will be perform in this project to observe the changes in speed response. Other than that, several operating condition such as the forward and reverse speed operation, load disturbance and step reduction of various speed command are implemented to study the speed performance of the driver system in term of overshoot, undershoot, rise-time, settling time, speed and recovery time. Lastly, this project will be separated into two part, which is the simulation part and experimental part. Simulation part will be on the design of a Simulink model for the purpose of study the speed behavior of the motor drive. Whereas for the experimental part, hardware will be implemented and collaborated with SIMULINK and dSPACE to see the synchronization level of the speed response between the simulations part result and experimental part result. The result will be explained and shown in graph form by using the Matlab/Simulink software.

ABSTRAK

Tujuan projek ini adalah untuk menggunakan pengawal logik kabur (FLC) dalam mengawal kelajuan pemacu motor segerak magnet kekal (PMSM). Parameter tetap yang dikawal dengan kawalan logik kabur dalam pemacu motor segerak magnet kekal akan dikaji semasa fasa pemulaan dan fasa gangguan dan seterusnya akan dibandingkan dengan parameter rujukan untuk memperhatikan prestasi penurunan kelajuan motor. Selain itu, kajian untuk membuat penalaan fungsi keahlian untuk kelajuan yang berbeza akan dilaksanakan dalam projek ini bagi memerhati tindak balas perubahan dalam kelajuan. Selain daripada itu, beberapa operasi seperti operasi kelajuan depan-belakang, gangguan beban dan pengurangan langkah dari pelbagai perintah kelajuan akan dilaksanakan untuk mengkaji prestasi kelajuan sistem pemandu dari segi lajak, lajak bawah, masa naik, masa pengenapan, kelajuan dan masa pemulihan. Akhir sekali, projek ini akan dibahagikan kepada dua bahagian, iaitu bahagian simulasi dan bahagian eksperimen. Bahagian simulasi adalah pada reka bentuk bagi model SIMULIINK bertujuan mengkaji tingkah laku kelajuan pemacu motor. Manakala bahagian eksperimen, perlaksanaan perkakasan dan kerjasama dengan SIMULINK dan dSPACE untuk melihat tahap penyegerakan tindak balas kelajuan antara hasil bahagian simulasi dan hasil bahagian eksperimen. Hasilnya akan diterangkan dan ditunjukkan dalam bentuk graf dengan menggunakan perisian MATLAB/SIMULINK.

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LIST OF ABBREVIATIONS

AC	-	Alternate Current
DC	-	Direct Current
DSP	-	Digital Signal Processor
FL	-	Fuzzy Logic
FLC	-	Fuzzy Logic Controller
IGBT	-	Insulated Gate Bipolar Transistor
PMSM	-	Permanent Magnet Synchronous Motor
PWM	-	Pulse Width Modulation
RPM	-	Revolution per Minutes
VSI	-	Voltage Source Inverter

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In concern with the advancement of technology and application in this era, high performance of motor drive are needed to scope this requirement. Therefore, a lot of motor drive have been introduced by the professional to the society so that the requirement of high performance motor drive can be fulfill.

Nowadays, Permanent Magnet Synchronous Motor (PMSM) Drive is very popular in high performance variable speed drive due to its high power density, high efficiency, high power factor and low inertia characteristic. Besides, permanent magnet synchronous motor (PMSM) drive are also good in conserve energy compare to other nonlinear motor drive. Permanent magnet synchronous motor (PMSM) drive can be categorized into two types depending in the control strategy with the inverter supply system. The two types are the rectangular wave electronically commutated permanent magnet synchronous motor which is also known as Brushless DC (BLDC) motor and the sinusoidal wave fed Permanent Magnet Synchronous Motor (PMSM) which is known as permanent magnet synchronous motor.

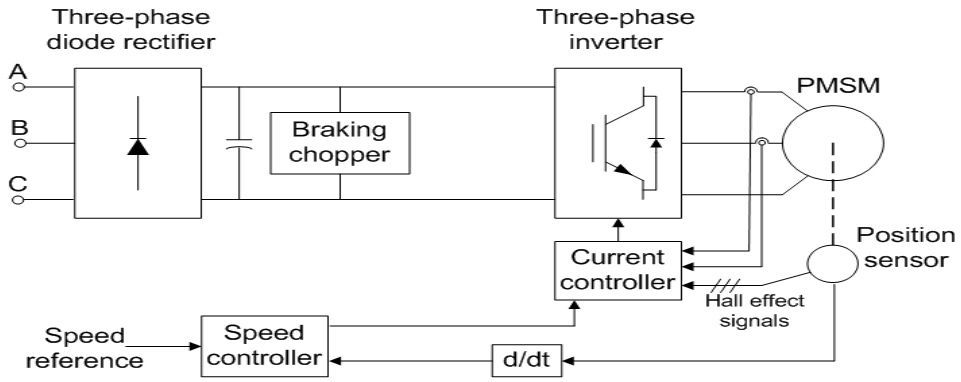

Figure 1.0: Basic scheme of permanent magnet synchronous motor

The speed controller used in the speed control system plays an important rule as it need to meet the criteria of the high performance drive. Conventional controller such as the Proportional (P) controller, Proportional Integral (PI) controller, and Proportional Integral Derivative (PID) controller can't achieve the high performance in the speed control as there are a lot of aspect need to be take into consideration. The aspect are the changes in transient response, error integral , unknown dynamic and other factors such as noise and temperature. These changes of factor will causes the output to be shattering from the required output.

Besides, these conventional controller required accurate mathematical model to describe the dynamic of system under control and required fine tuning for the parameter variations. Lastly, the conventional controller design depend only on the exact system with accurate motor parameter and its fixed gain controller are sensitive to system disturbance.

Therefore, Fuzzy Logic Controller (FLC) controller are recommend to be used in this speed control system. This is because FLC are simpler than the other controller schemes since it doesn't need complicated mathematical manipulation and it only have 3 stages for the conversion of output torque from the speed error and the rate of change of speed error. The three stages are the fuzzification, rule execution and defuzzification. These three stages are important as it will produce the desired output for the speed controlling command.

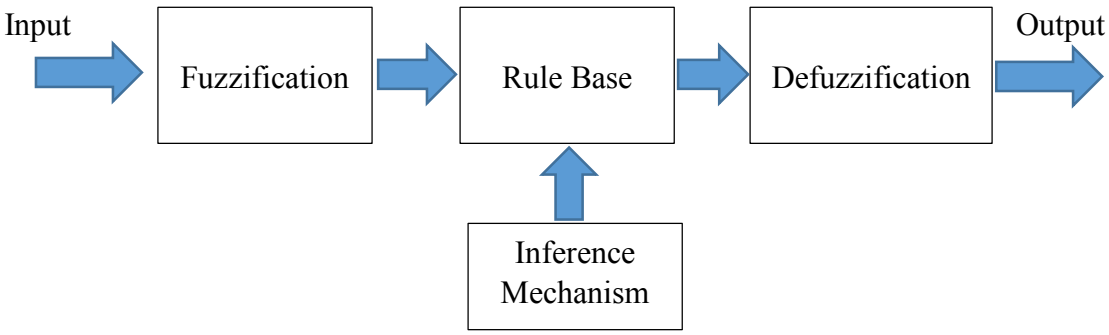

Figure 1.1: Basic structure of fuzzy logic controller (FLC)

Other than that, FLC have high robust ability, low cost and less complex compared with other conventional controller. The biggest difference of this controller with conventional controller is that it execute a set of control rule by following a rule base. The rule base is the IF X AND Y, THEN Z rules. Membership function also play an important roles in FLC, it need to be chosen such that it cover the whole universe of discourse. Other than that, the membership function should also overlapping with each other so to avoid any kind of discontinuity with respect to the minor changes in the inputs.

Besides, several technique such as the adaptive control, neural network control, robust control and variable structure control are introduced to overcome the nonlinearity problem and improve the dynamic response of the sinusoidal permanent magnet synchronous motor drive (PMSM) with fuzzy logic control system.

Fuzzy logic controller (FLC) solves the problem of nonlinearities and parameter variations of sinusoidal permanent magnet synchronous motor (PMSM) drive. Addition, it can achieves high dynamic performance and accurate speed control with good steady-state characteristics. The control performance can be seen in the MATLAB SIMULINK simulation with various operating with it.

1.2 Problem Statement

Over the decade, the usage of fuzzy logic controller have been increase in the power electronic and automotive field. This is mainly because of the easy tuning features of the fuzzy logic and the simple structure of the fuzzy logic controller which ease the implementation of the controller to the machine or system. Fuzzy logic controller is easy to implement compared to other current controller such as the Proportional Integral (PI) Controller and Proportional Integral Derivative (PID) Controller. The fixed controlled parameter of fuzzy logic controller will degrade the speed performance for different speed command. Therefore, the fixed controlled parameter need to be keep constant so that the speed performance behaviour will be constant. However, the re-tuning and designing of membership function in FLC for difference speed command is one of the problem facing in this project since there is a lot of way to design the membership function [1]. It is hard to decide which range and shape of the membership function should use for this project. Besides, it is also difficult in changing and tuning the fuzzy logic controller (FLC) in order to obtain good speed response since FLC have variation of rule [2]. The designing and tuning of the fuzzy logic controller are all by trial and error method, which mean that the process are time consuming and depend on the knowledge and experience of the user to design and utilize the fuzzy logic controller.

As a summary, the problem statement are:

I. The fixed controlled parameter which will degrade the speed performance for different speed command.
II. The re-tuning and designing of membership function in fuzzy logic controller (FLC) for difference speed command.
III. The difficulty in changing and tuning the fuzzy logic controller (FLC) in order to obtain good speed response since FLC have variation of rule

1.3 Objective

The objective of this project are:

I. To design and develop a fuzzy logic controller using Matlab Simulink.

II. To investigate and analyze the speed response behavior of the drive which vary with the constant parameter of fuzzy logic.

III. To study the correlation between rule base and membership function in speed response behavior.

IV. To implement the fuzzy logic speed controller to the PMSM drive.

1.4 Scope

The project mainly focuses on:

i. The mathematical model of vector control of permanent magnet synchronous motor (PMSM) drive.
ii. The control of fixed controller parameter of a sinusoidal permanent magnet synchronous motor (PMSM) drive by using fuzzy logic controller.
iii. The modelling and simulation of Fuzzy Logic Controller (FLC) for permanent magnet synchronous motor (PMSM) drive using Matlab or Simulink.
iv. The experimental evaluation on the performances of Fuzzy Logic Controller (FLC) in permanent magnet synchronous motor (PMSM) drive in terms of switching frequency and current control.