HYBRID PI AND FUZZY LOGIC SPEED CONTROLLER STRATEGY FOR INDUCTION MOTOR DRIVE

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DECLARATION

I declare that this thesis entitled "Hybrid Pi And Fuzzy Logic Speed Controller Strategy For Induction Motor Drive" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	--
Name	:	--
Date	:	--

APPROVAL

I hereby declare that I have checked this report entitled "Hybrid Pi And Fuzzy Logic Speed Controller Strategy For Induction Motor Drive" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature	:	....
Supervisor Name	:	....
Date	:	....

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Induction motor is the horse power of the industry since long time ago due to its cheaper price, simple construction and maintenance free. The induction motor is increasingly popular when the speed of the motor can be control which make it speed variable. Popular controller that be used to control the speed of the Induction Motor is PI controller and also Fuzzy Logic Controller. These two controllers have its own problem which is for PI, it is easy to undergo overshoot and undershoot when in the transient state. PI controller also sensitive to parameter variation and load variation which is can reduce the performance of the Induction Motor. For FLC, the main problem is about its steady state error when in steady state conditions. So, in this research the objective is to applied Hybrid PI and FLC strategy for Induction Motor to make use of the advantage of both controllers. In this research, the method that been used is Field Oriented Control (FOC). FOC was developed in the early 1970s and made it feasible to control the induction motor as a separately excited DC motor. The result of the performance between PI,FLC and Hybrid controllers have been discussed and the Hybrid PI and FLC have a better performance compare to other two controllers in the terms of speed performance, speed drop, rising time and also speed drop.

ABSTRAK

Motor induksi adalah kuasa kuda industri sejak lama dahulu kerana harga yang lebih murah, pembinaan mudah dan penyelenggaraannya percuma. Motor induksi semakin popular apabila kelajuan motor dapat mengawal yang menjadikannya pemboleh ubah laju. Pengawal yang popular yang digunakan untuk mengawal kelajuan Motor Induksi adalah pengawal PI dan juga Pengawal Logik Fuzzy. Kedua-dua pengawal ini mempunyai masalah tersendiri yang digunakan untuk PI, mudah untuk melakukan overshoot dan kekurangan ketika berada dalam keadaan sementara. Pengawal PI juga sensitif kepada variasi parameter dan variasi beban yang dapat mengurangkan prestasi Motor Induksi. Bagi FLC, masalah utama adalah mengenai keadaan keadaan mantapnya apabila keadaan keadaan mantap. Jadi, dalam kajian ini matlamatnya adalah menerapkan strategi Hybrid PI dan FLC untuk Induksi Motor untuk memanfaatkan kelebihan kedua pengawal tersebut. Dalam kajian ini, kaedah yang digunakan ialah Kawalan Berorientasi Lapangan (FOC). FOC telah dibangunkan pada awal 1970-an dan menjadikannya layak untuk mengawal motor induksi sebagai motor DC yang teruja secara berasingan. Hasil daripada prestasi antara PI, FLC dan pengawal Hibrid telah dibincangkan dan Hybrid PI dan FLC mempunyai prestasi yang lebih baik berbanding dua pengendali lain dalam segi prestasi kelajuan, penurunan kelajuan, masa yang semakin meningkat dan juga penurunan kelajuan.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	-	Alternate current
DC	-	Direct Current
FLC	-	Fuzzy Logic Controller
IM	-	Induction Motor
PI	-	Proportional Integral
V/F	-	Voltage/Frequency
DTC	-	Direct Torque Control
FOC	-	Field Oriented Control
IFOC	-	Indirect Field Oriented Control

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Three phase induction motors are the most widely used for industrial control and automation for variable-speed applications. They are often called the workhorse of the motion industries and known to be superior to their DC counterparts concerning to their robustness, reliability, less maintenance and high durability [1-35]. The application of the induction motor in industry is increase from day to day due to its variable speed approach. The advance in process and control of power electronic device have given a better result in the control of speed induction motor by using a suitable controller.

Control of Induction Motor (IM) is well known to be difficult due to its linearity problem. There are three basic control method for induction motor which are Scalar Control, Field Oriented Control (FOC) and Direct Torque control (DTC). The most commonly used controller for the speed control of induction motor is Proportional Integral (PI) controller. The simplicity and robustness of PI controller make it popular and mostly used in motor drive.

Other controller like fuzzy also can be used to control the speed of the induction motor make it reliable and speed variable. The hybridization of PI and fuzzy logic controller increase the performance of induction motor and make the speed of the motor controllable. This research is focus on applied Hybrid Fuzzy and PI speed controller strategy for the Induction Motor. The aim of the research is to eliminate the weakness that was discuss in PI and FLC Controller and improve the performance speed control of the induction motor.

1.2 Problem Statement

An induction motor has quite simple construction that need less maintenance compare to DC motor but an induction motor has difficulties in controlling its speed. Generally, PI controller has been widely used to control the speed of the induction motor and other motor drive system. The problem of this controller is sensitive to parameter variation and load variation. PI controller also have other problem which is occurrence of overshoot and undershoot while in the transient state condition. Nowadays, FLC has become well known among the people across the world. FLC has been widely used in many applications such as washing machine, air-conditioner, vacuum cleaner and many mores. The problem with fuzzy logic speed controller is it has steady state error during the steady-state condition. FLC has better performance compare to PI controller in terms of transient performance, parameter variation and also load disturbance. In order to overcome the weakness of PI and FLC, hybridization of FLC and PI was introduced. In this research, we will focus on speed controller Hybrid PI and FLC for the induction motor.

1.3 Objective

This report presents the development of speed controller for motor drive. The controller that been proposed is Hybrid PI and FLC speed controller. The study focuses on the following objectives:

i) Model an induction motor based on d-q model through Simulink, MATLAB.

ii) Develop FLC controller, PI controller and Hybrid controller for induction motor.

iii) Analysis the performance of the speed induction motor with different controller PI, FLC, and Hybrid speed controller.

1.4 Scope

The research on this project is conduct as follows:

i) First of all, this research focus on the literature review that includes an induction motor model, current control method and also speed controller.

ii) Based on the motor parameter that taken from previous research, the induction motor and hysteresis current is modelled. The simulation is carried on by using MATLAB/Simulink to analyze the speed performance of the induction motor model.

iii) PI, FLC and Hybrid PI and Fuzzy speed controller is applied on the induction motor model to compare the performance among the controller. The tuning method that used for PI is trial and error due to its simplest and easiest way of tuning. For fuzzy, the membership function that used is 5x5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss on the overview of the induction motor with a few controllers that will be used in this research. In this chapter also will focus on the previous research on the other controller like PI controller and also FLC. The comparison of the performance between the controller will be discuss later in this chapter.

2.2 Induction Motor

Induction motor always draws attention in industry application due to its well-known simplicity and robustness. Induction motor has been used in many applications nowadays due to its variable speed such as fan, blowers, compressor, bulldozer and many more. This variable speed application can be achieved through applying power electronic drive in the induction motor. With the advance in the power electronic drive, the control speed of induction can be easily control. The construction of an induction motor has the same physical stator as other synchronous motor but the construction of the rotor was different. There are two type rotor of induction motor which is a squirrel cage rotor and a wound rotor.

The most important advantage of induction motor is about the construction. Its simple construction that does not have brushes compare to DC motor made it free from maintenance. Induction motor also working independently in any environmental condition due to its robust and mechanically strong. The cost of the squirrel cage induction motor is quite low because induction motor doesn’t have brushes, slip ring and also commutators. Three phase induction motors have a high starting torque, good speed regulation and reasonable overload capacity. Induction motor also has its own disadvantage. For single phase induction motor, it has no self-starting torque. So, it needs auxiliaries to start. The speed control of induction motor is very difficult to attain due to its linearity problem and also constant speed of the motor. Induction motor also have high input surge currents that will cause reduction in voltage at the time starting motor.

Table 2.1: Comparison between Induction Motor, Brushed DC Motor and Brushless DC Motor.

Feature	Induction Motor	Brushed DC Motor	Brushless DC Motor
Efficiency	Low – Heat and current losses in both rotor and stator	Moderate – Losses in the brushes	High – No losses in the brushes
Maintenance	Low maintenance	Periodic maintenance	Low or no maintenance
Cost	Low	High	High
Controller requirements	No controller for fixed speed. Controller required for variable speed.	No controller for fixed speed. Controller required for variable speed.	A controller is always required to control the commutation sequence
Speed range	Depend on AC frequency	High	Moderate

2.3 Induction Motor Concepts

The speed of induction motor based on the system frequency and also number of poles. The AC voltages that supply the stator will produce rotating magnetic field B_s. The induced voltage will be created when the rotating magnetic field B_s passed over the rotor bars. The rotor current that flow in the rotor would be lagging. Then, the current will create a magnetic field at the rotor, Br. Acceleration was generating in the motor due to induced torque then makes the motor spin. There is a finite upper limit to the motor’s speed. An induction motor will never reach synchronous speed but it can reach near synchronous speed [4].

2.4 Equivalent Model of Induction Motor

The induction motor operating based on the induce voltages and currents in its rotor circuit from the stator circuit. Overall, the operation of the induction motor has similarity to the transformer's equivalent circuit. The equivalent circuit for induction motor can be represent by a transformer per – phase equivalent circuit as shown in Figure 2.2.

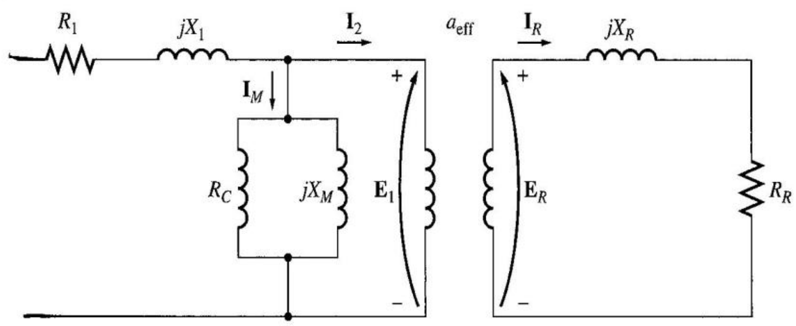

Figure 2.1: Equivalent circuit of an induction motor.

WhereR_1 is stator resistance, R_R is rotor resistance, X_1 is stator leakage reactance, X_M is magnetizing reactance, X_R is rotor leakage reactance.

2.5 Control Method for Induction Motor

In order to control induction motor, a few control techniques must be applies to make sure the controllability of induction motor. The control method that can be used in induction motor drive is Field Oriented Control (FOC) and aldso Direct Torque Control (DTC). Field oriented control (FOC) is the most popular and been used among the other vector control. The other method for vector control that been used is direct torque control (DTC). In this project, vector control FOC was proposed and be used. The torque and flux magnitude control can be achieved by using FOC control method. To use FOC control method, the mathematical model of induction motor must be converted into d-q model which separate d and q components of the stator current that used for flux and torque production. These components are decoupled and controlled individual [34]. DTC is based on two principles where the first principle relates to the stator flux change and stator voltage in the stator equation. In DTC, torque can be controlled by changing the relative angle between flux stator and flux rotor.

2.5.1 Direct Field Oriented Control

The direct method of field-oriented control, which was originally proposed by Blashke [21] is shown in Figure 2.2. This technique utilizes direct sensing of the air gap flux vector by using one of the measurement techniques.

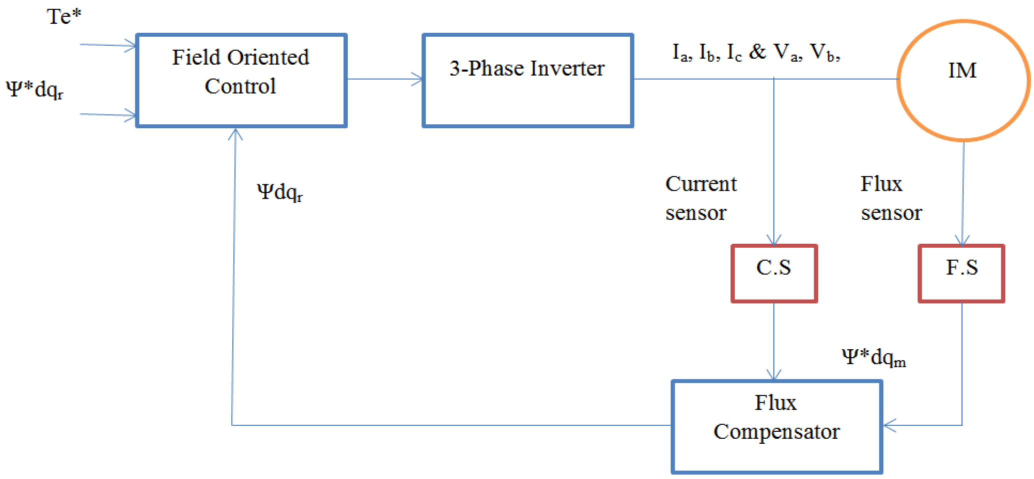

Figure 2.2: Direct flux sensing of induction motor vector control system

The measured air gap flux signal is feedback to the control and used to decouple the torque producing component of stator current from the producing component. Since this method uses feedback control and direct sensing of the regulated variable, it is essentially insensitive to variations.

2.5.2 Indirect Field Oriented Control

The indirect method of field-oriented control, was originally proposed by Hasse [22] is shown in Figure 2.3. This method avoids the requirement of flux acquisition (sensing devices) by using known motor parameters to compute the appropriate motor slip frequency to obtain the desired flux position [1]. On the other hands, the rotor flux is estimated from the stator current vector, voltage vector and or rotor speed, and then this estimate is, in effect, fed forward to the flux and torque controllers [29]. This scheme is simpler to implement than the direct method of (FOC). Hence, there is an increasing popularity towards the indirect method of (FOC).