UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FACULTY OF ELECTRICAL ENGINEERING

FINAL YEAR PROJECT REPORT

DEVELOPMENT OF FIVE PHASE INDUCTION MOTOR SPEED USING FIELD ORIENTED CONTROL METHOD

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DEVELOPMENT OF FIVE PHASE INDUCTION MOTOR SPEED USING FIELD ORIENTED CONTROL METHOD

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A report submitted

in partial fulfillment of the requirements for the Bachelor in Electrical Engineering (Control, Instrumentation and Automation)

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2015

DECLARATION

I declare that this report entitle “Development of Five-phase Induction Motor Speed using Field Oriented Control Method” 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 the candidature of any other degree.

Signature : ....

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Date : ....

APPROVAL

I hereby declare that I have read through this report entitle “Development of Five-phase Induction Motor Speed using Field Oriented Control Method” and found that it has complied the partial fulfillment for awarding the Bachelor in Electrical Engineering (Control, Instrumentation and Automation)

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ABSTRACT

Multiphase induction motor drive is considered for various applications. Utilization of AC machines with a number higher than three phase can be enabled using power electronic in electrical drives. The 5-phase motor drive has many advantages compared to 3-phase such as reducing amplitude of torque and current pulsation. The aim of this project is to control the speed of five phase induction motor using Field Oriented Control (FOC). A five phase induction motor has high fault tolerance. The main application of multiphase induction motor are ship propulsion, traction (including electric and hybrid electric vehicles) and electric aircraft. In order to run a five phase induction motor, the drive system need to be designed. Five phase source supplied from five-phase Voltage Source Inverter (VSI) space vector modulation has chosen as the switching scheme due to its easiness of digital implementation. Space Vector Modulation (SVM) gives effective control of multiphase VSI because of higher switching voltage capacity compare to its companion. The Field Oriented Control (FOC) has been selected as a method to control the speed of five phase induction motor. FOC controlling the current space vector directly in the d-q rotor reference frame. Once the stator current is transformed, the control becomes rather straight forward. Two PI controller is used for d and q. This will maximize the torque efficiency and increase the speed. The FOC will also provides smoother motion at slow speeds as well as efficient operation at high speeds. The result is shown in simulation and can be experimental on real five phase induction motor with five phase inverter.

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

For this project, the speed of the motor has control by field oriented control (FOC) technique. The five-phase Voltage Source Inverter (VSI) is used to run five-phase induction motor. Space vector modulation (SVM) is chosen as the switching scheme due to its easiness in digital implementation. Space vector modulation gives effective control of multiphase VSI because of large numbers of space vectors. Voltage source inverter (VSI) implemented Insulated Gate Bipolar Transistor (IGBT). The speed of the motor should follow the reference speed that gives as input reference.

1.2 Project Motivation

Nowadays, multiphase motor drives considered for various applications which required zero fault. The five-phase motor drive has so many advantages compared to the 3-phase motor such as reducing amplitude of torque and current pulsation.

Five phase drives supplied from five-phase Voltage Source Inverter (VSI) and adequate method for VSI pulse width modulation are therefore required. For this project, space vector modulation schemes for a five-phase VSI generated to drive five phase induction motor and Field Oriented Method will be used to control the speed of the five phase induction motor.

1.3 Problem Statement

From the previous project, the five phase induction motor simulation scheme was successfully created and was able to run with constant speed input. The speed of the five phase induction motor is yet to be controlled. To control the speed of the five phase induction motor, the control scheme to be designed.

1.4 Objective

The research objectives are:

i. To control the speed of the five phase induction motor using field oriented method.
ii. To design the PID controller using voltage source inverter through space vector modulation scheme.
iii. To simulate the design using Simulink/Matlab and experiment using actual five phase induction motor in the lab.

1.5 Scope of Project

The scope of this project is running under the simulation using Matlab/Simulink and actual five phase induction motor control in a laboratory environment. Simulink software will be used for simulation of five phase motor drives purposes. The previous project was successfully create switching scheme for the five phase induction motor using Space Vector Modulation (SVM) method. So, for this project, the speed controller, which is Field Oriented Control (FOC) method will be added in order to control the speed of the five phase induction motor. After that, the controller will be simulated in Matlab/Simulink. Lastly, the control and inverter design will be tested in the laboratory using the actual five phase induction motor. The test will be conducted using the actual five phase induction motor, its drives and dspace controller, which is available in the research laboratory.

1.6 Expected Project Outcome

The expected project outcome is the controller is able to control the speed of the five phase induction motor. Besides, able to modeling the simulation block diagram by using simulink for five phase induction motor, five phase inverter circuit and space vector modulation block diagram which is used for switching DC to multiphase AC. The purpose is to fed the induction motor. Other than that, designing PID controller and able to control the d-q components and also to control the speed of the motor. Next, able to model Clarke, park and ipark transformation which is to convert five-phase AC into dq component and from dq component back to five-pahse AC.

Lastly, able to analyse the speed response of the motor and tune PID controller dq components and analyse Vd and Vq response for drive and five phase induction motor. After that capture the response graph in simulation and run experimental on real five phase induction motor using real five phase induction motor using real five phase inverter inverter and capture motor speed response using an oscilloscope and real data capture on Matlab/Simulink.

CHAPTER 2

LITERATURE REVIEW

2.1 Previous Work

Induction motor that consists of three phase surely known advantages of basic development, reliability, roughness, low maintenance and cost which has led to their far reaching use in numerous mechanical operations [7]. Nowadays, more published work has demonstrated that drives with more than three-phase have more advantages over ordinary three-phase such as lower torque and reduction in harmonic currents [7]. From the previous work, the speed response of the motor was controlled by using Space Vector Modulation (SVM). SVM was chose because of its easiness of digital implemetation. Besides, SVM gives better control of multiphase Voltage Source Inverter (VSI) because the numbers of space vector is large [8].

For the previous work the speed of the motor was controlled by using space vector modulation scheme that was used for five-phase VSI to drive five-phase induction motor [8].

2.2 Induction Motor

The induction motor is the one of the most common electrical motor use. This motor runs at speeds lower than synchronous speed and it also known as a synchronous motor. The speed of rotation of the magnetic field in a rotating machine called as synchronous speed. Frequency and number of the machine influence synchronous speed of the motor. Flux generated in the rotor by the rotating magnetic field in the stator make the rotor to rotate.

There will be lag for the flux in the stator and rotor that makes the rotor cannot reach the synchronous speed. That's why the speed of the induction machine always less than synchronous speed. Induction process occurred in the induction motor.

The working principle of the induction motors is as follows. When give supply to the stator winding, the flow of current in the coil will generate the flux in the coil. The arrangement of the rotor winding will make it becomes a short circuit in the rotor itself. When the rotor coil is short circuit, current will flow in the coil of the rotor because the flux of the stator cut the coil of the rotor. The flowing current will generated another flux in the rotor. There will be two fluxes that are stator, rotor flux, and the stator flux will lead the rotor flux. Due to this, the rotor will produce a torque that makes the rotor to rotate in the direction of rotating magnetic flux. Therefore, the speed of the rotor will be depending upon the AC supply and the speed can control by varying the input supply.

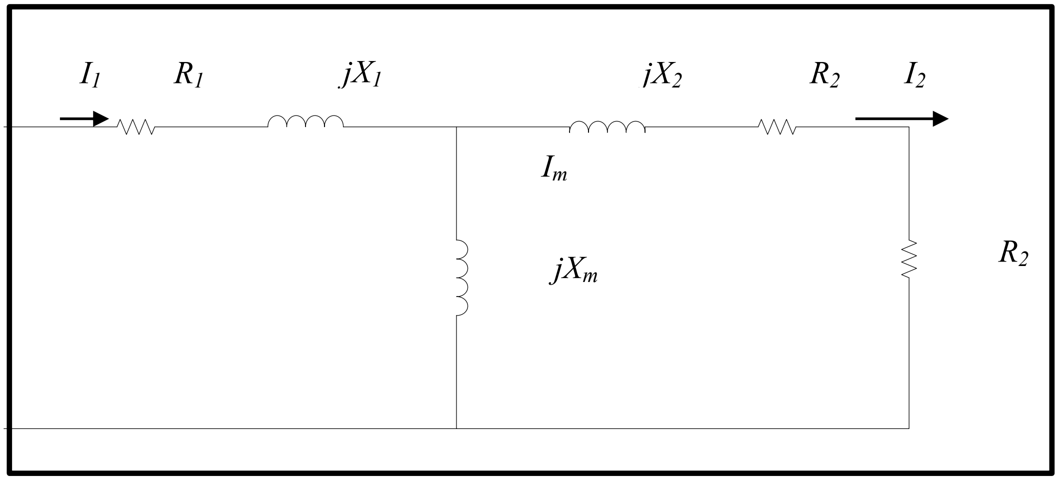

Figure 2.1:Per phase equivalent circuit for induction motor.

2.3 Multiphase Induction Motor

Induction motor more than three-phase have same properties with three-phase induction motor that run without producing a twice line-frequency pulsating torque and accelerate theirs load from the rest. Multiphase induction motors not connected directly to three-phase supplies. Three-phase supply connected to the power electronic converter that drive excitation for the multiphase induction motor. The output of the converter must have the same phase with the stator winding of the motor.

Multiphase machine have some advantages compared to three-phase machine. One of the advantages of multiphase machine is the efficiency of the multiphase machine is higher than three-phase machine because of the multiphase machine produces a field with lower space-harmonic content at the stator excitation. Second, multiphase machine has greater fault tolerance than three-phase machine [1-2].

2.5 Space Vector Modulation

Space vector modulation supplies AC machine with desired phase voltage. The space vector modulation method of generating the pulsed signals fit the requirement and minimizes the harmonic contents. Note that the harmonic content determines copper losses of the machine that account for a major portion of the machine losses [3].

Interest in multi phase drives has increased in recent years due to several advantages when compared to three-phase drives. The multiphase drive has some advantages that are less torque ripple, less acoustic noise and losses, reduced current per phase or increased reliability due to additional number of phases. Space vector modulation (SVM) is one of the most popular choices because it easy digital implementation and better utilization of the available DC bus voltage [4-5]

Power circuit topology for five-phase voltage source inverter with star-connected load presented. Five-phase space vector modulation can be developed as three phase space vector modulation for a period of the fundamental frequency. It shows the basic ten large and ten medium switching vectors for five-phase inverter.

Total voltage space vector in five-phase inverter is 32 vectors, but only 22 vectors used, consists of ten large and ten medium active vectors and two zero vectors. This is to decrease the number of switching in inverter and decrease switching losses.

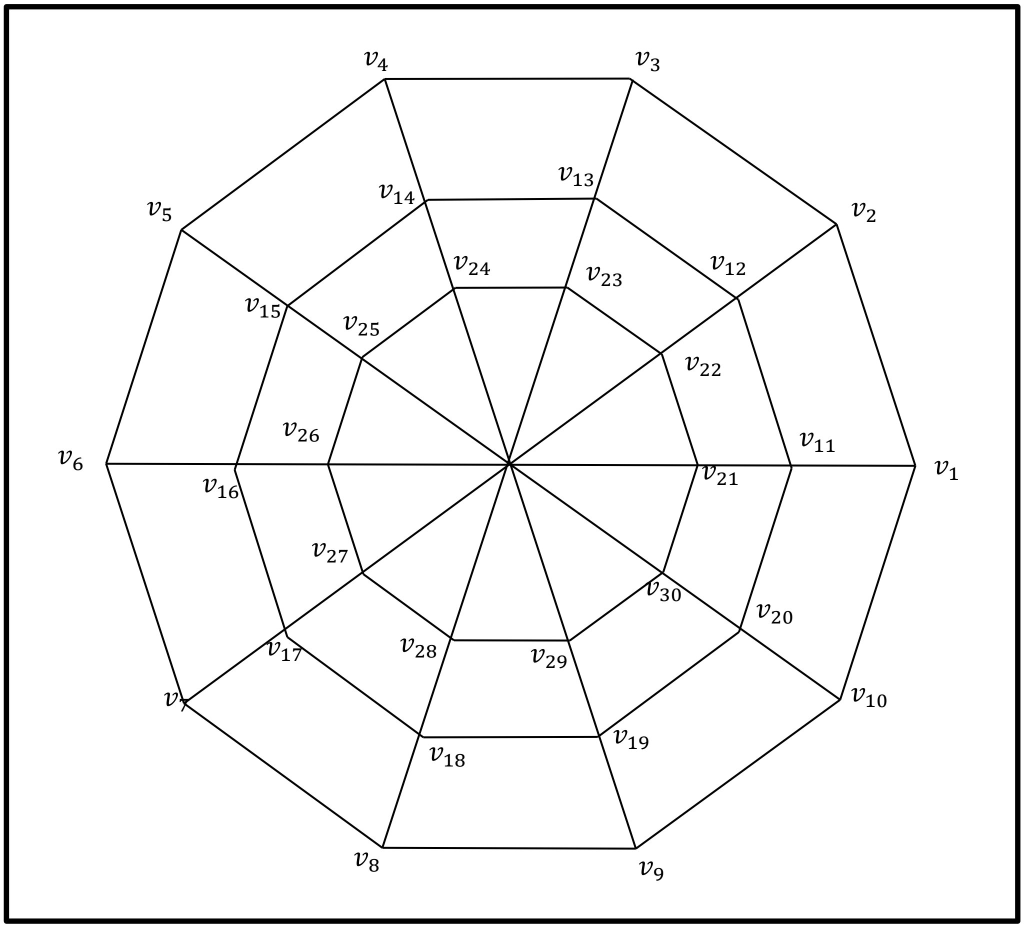

Figure 2.4:phase to neutral voltage space vector on dq plane

When five-phase operated in PWM mode, there will be additional 22 switching states. 2^n is the general equation for number of possible switching states, where n is the number of inverter leg. The remaining twenty-two switching states encompass three possible situations. First, all the states when four switches from upper (or lower) half and one from the lower (or upper) half of the inverter are „on" at state"s 11 until 20. Next, two states when either all the five upper (lower) switches are „on" at state"s 31 and 32. Last, the remaining states with three switches from the upper (lower) half and two switches from the lower (upper) half are „on" at state"s 21until 30.