



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Field Oriented Control of Five-phase Induction Motor Speed Drive Using DSpace and Matlab/Simulink

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electrical Engineering Technology (Industrial Power) with Honors'

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DECLARATION

I hereby, declared this report entitled “FIELD ORIENTED CONTROL OF FIVE PHASE MOTOR SPEED DRIVES USING DSPACE AND MATLAB/SIMULINK” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honors'. The member of the supervisory is as follow:

.....

(Project Supervisor)

ABSTRAK

Projek ini dilaksanakan untuk mengawal motor lima-fasa. DSpace digunakan untuk mengawal sistem dan simulasi Matlab/Simulink digunakan untuk menjalankan simulasi. Motor lima-fasa digunakan kerana banyak kelebihan berbanding dengan motor tiga-fasa. Diantaranya kekuatan tork motor menjadi lebih tinggi dan arus menjadi lebih rendah bagi setiap fasa. Selain itu, motor lima-fasa juga amplitud tork dapat dikurangkan. Tambahan lagi, kadar denyutan dimasa kelajuan tinggi dapat diminimumkan. Gelombang sinusoidal yang sempurna perlu dijana supaya motor dapat digerakkan. Kelajuan motor haruslah mengikuti kelajuan rujukan yang dapat diklasifikasi sebagai input. Prestasi motor lima-fasa telah direkodkan bagi tujuan laporan prestasi projek.

ABSTRACT

This project consider for controlling speed of five-phase induction motor. DSpace have been used for system controlling and Matlab/Simulink is used for simulation. Five-phase motor is used because there are many advantages compare to three-phase motor. As the torque strength become more high and current become more low for each phase. Other than that , five-phase motor able decrease torque amplitude. In addition , pulse rate in high speed can be minimalized. Perfect sinusoidal wave must be generate in order to run the motor. Motor speed must follow the reference and can be classified as input. Five-phase motor performance have been record for project performance report.

DEDICATION

Special dedication to my beloved parent Mr Razlan Bin Awang Zakaria and Mrs. Halijah Binti Puteh. Both of my sisters Ruhila Zahra binti Razlan and Hazira Hafsa Binti Razlan and my only brother Amir Sirhan Bin Razlan. I also dedicated for my loving one Nur Jannah Binti Ahmad Tegoeh Soebagijo. May Allah bless all of us, Amin...

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Alternate Current
BJT	-	Bipolar junction transistor
CPU	-	Central Processing Unit
CRT	-	Cathode Ray Tube
DC	-	Direct Current
FOC	-	Field Oriented Control
GUI	-	Graphic User Interface
IGBT	-	Insulated Gated Bipolar Transistor
MOSFET	-	Metal-Oxide Semiconductor Field Effect Transistor
PWM	-	Pulse Width Modulation
RMS	-	Root Mean Square
VSM	-	Vector Space Modulation

CHAPTER 1

INTRODUCTION

1.0 Project Overview

This project, rely on control of five-phase motor using Field Oriented Control (FOC) using MATLAB simulation and DSpace. Nowadays, controlling speed of five phase motor becomes important aspect in many industries. The main objective of motor speed control is to keep motor at desired speed. In this project, DSpace will control five-phase induction motor. DSpace act as controller for fast voltage and current measurement. The DSpace is digital signal processor that will be connected to computer and will operated in real time. DSpace will connect to drive hardware and to motor using DSpace connector. DSpace also will control the parameter that tuned in computer. For speed, the project varies the frequency by using FOC by using of an inverter. The switching scheme will be applied to an inverter. The sinusoidal pulse width modulation switching scheme have used to find the signal. The FOC is used for switching the inverter to drive five-phase induction motor.

1.1 Motivation

Nowadays, five-phase motor is the motor that widely used. Five-phase motor can be class in poly- phase motor drive system. This because the five-phase motor has good efficiency, high power factor, feature good start, and rugged construction compared with three phase induction motor. Other than that, the advantage is characteristic to the own structure of the machine, such as reduce amplitude, frequency of torque pulsation increase, harmonic current losses at rotor reduce, and dc link current

harmonics become lower. This project will use five-phase inverter as motor drive power supply. MATLAB software is used for controlling the speed of five-phase induction motor. With this software, designation of five-phase motor speed controller will be done. DSpace will act as interfaces to control the motor speed.

1.2 Problem Statement

The contemporary advance in the area of FOC bring the fast development and cost saving of power electronic devices for five-phase induction motor give more cost-effective for numerous industrial applicants. However due to complexity of induction motor will cause problem. Several parameters such as load torque, rotor and stator resistance may vary significantly during operation. In this venture the main issue is control speed of induction motor as fast response. As countermeasure, the suitable controller and drive must be design to improve the efficiency of motor to use. This venture is to vary frequency source, the converter is needed to the source of frequency.

1.3 Project Objective

This project is triggered by a problem in controlling a five-phase induction motor speed and torque. Controlling Alternating Current (AC) five-phase motor can be quite challenging. We can use some of different technique such Pulse Width Modulation (PWM), FOC, Vector Space Modulation (VSM). So, this venture is work on controlling motor speed using MATLAB/Simulink and DSpace. In order to achieve the objective few things need to be accomplished before the project can be done:

1. Design a five-phase AC induction motor drive with low stator current using Field Oriented Control to control the motor speed
2. Simulate experimental of 5 phases using Proportional Integral Derivative(PID) controller and collect the related data for performance analysis

3. Run experimental five-phase AC motor drive and its speed controller using DSpace to analyze the mechanical and electrical performance in real time environment

1.4 Project scope

This project will be undertaken in some stages that will make this project success. First thing is to study five-phase induction motor. This will help to understanding how this system working. Firstly, create the motor drive. Then, participate the digital implementation on DSpace. Finally, to analyze performance of motor run due on simulation result and experimental result.

1.5 Report Outline

This report contains five chapters that explain in the aspect of whole project to deliver understanding of the whole project.

Chapter 1- Project Introduction

This chapter offerings an overview of the project, project motivation, problem statement, project objective, project scope and expected project outcome.

Chapter 2- Literature Review

This chapter deliberates about source and article that related to the project. This chapter also comprehends the system of the component, equipment and programming that used in the project. This will help to understanding the concept of the project.

Chapter 3 – Project Methodology

This chapter covers up all the project application to achieve the objective of the project. This chapter contains the technique and procedures to complete the project. It also contains the step taken for entire task to comprehensive the project. All method and procedure to generate the expected results and the software technical detail also explained in this chapter.

Chapter 4 – Result and discussion

This chapter comprehend the result and analysis of the project that been done. the result and expected result also discuss in this chapter.

Chapter 5 –Conclusion

This chapter contains the conclusion that can achieve from the project and the recommendation to extemporize project.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter briefly discusses the five-phase AC motor characteristic and part. Then, will explain about inverter and its function and component. It also will discuss about development of five- phase AC motor drive using MATLAB/Simulink. Many theories have been proposed to develop AC controller and motor drive. With this study we must carried out how to develop and make improvement in AC controller and motor drive. Although, the literature includes many theories, this study will be focused on development of AC controller and motor drive using MATLAB/Simulink and DSpace as interface. However other information from past researcher will also be included in this chapter for the reader to understand more in this project.

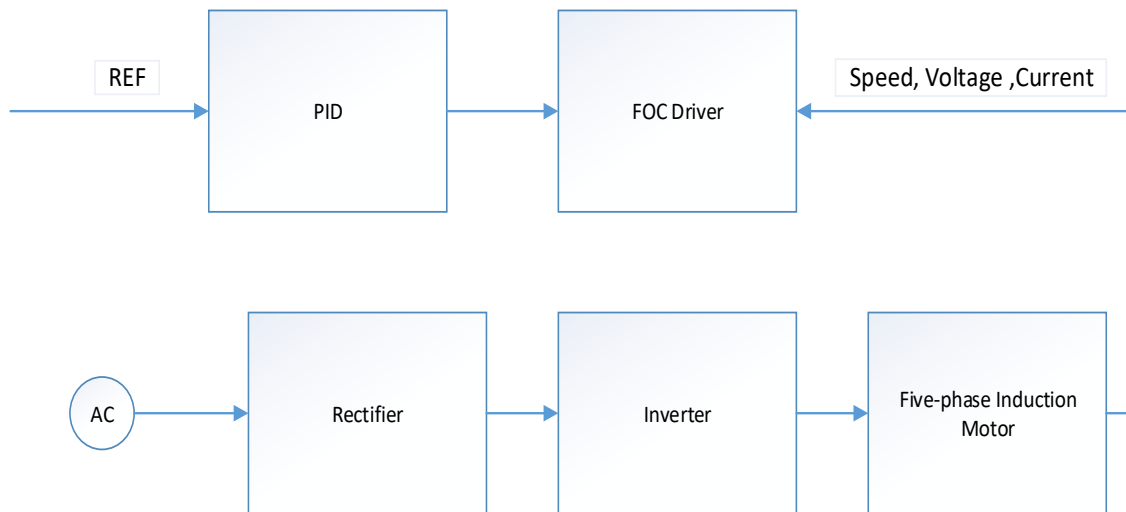


Figure 2.1: Total system block diagram

2.1 Induction Motor

Induction motor is very general and extensively used in electrical industry. Induction motor will run at constant speed from no load to full load. However, these motors depend on frequency to control the speed. This characteristic makes the motor runs at constant speed because the speed can't have changed easily. This factor make the DC motor is better in term dealing with speed variation. According to R. H. Sagor [1] induction motor is simple, durable, low prices, easy to maintain and can be made features to suit most requirement of the industries. According to F. Semiconductor [2], the most popular type is the 3-phase, squirrel cage AC induction motor. It is maintenance-free, less noisy and efficient motor.

2.2 Five-Phase Induction Motor

Induction motor also called asynchronous motor in motor. The entire rotor's energy is produced from the magnetic field of the stator winding to electromagnetic induction. An electric motor converts electrical energy into mechanical which supplies in different types of loads. AC motors operate on an AC supply, and they are synchronous, single phase and 3 phase induction and special purpose motors. There also has multi-phase motor, 5 phase induction motor is classified in multi-phase motor. Multi-phase motor most widely used in industrial applications mainly because they no require starting devices. An induction motor not requires mechanical commutation for all or part of the energy transferred from stator to rotor. An induction motors can be both wound and the type. Squirrel cage motor induction motors are widely used in industrial drives because there are rugged, reliable and economical. Advantages of induction motor its simple in term of mechanically. This leads not only inherent reliability, but also to simpler design to shock requirement.

2.3 Inverter

Inverter is an electronic devices or circuitry that changes direct current (DC) to alternate current (AC). This equipment is widely used in electrical system and commonly found on electrical generation system. A power inverter can be entirely electronic or may be combination of mechanical effect and electronic circuitry.

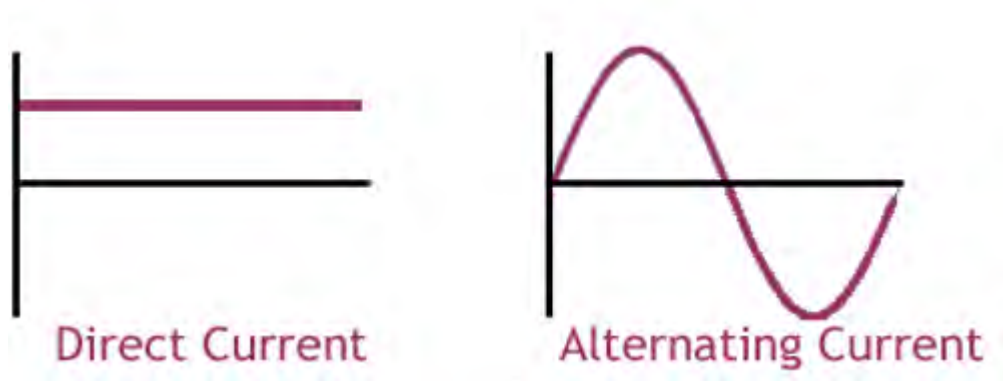


Figure 2.2: Waveform DC to AC

The function of an inverter is to change a DC input voltage to symmetric AC output voltage of desired magnitude and frequency [3]. According Norazelina Binti Kamisman [4], inverting in power electronic denotes a class power conversion circuits that operates from DC voltage sources or a DC current source and converts it into AC voltage or AC current. The inverter is the reverse of the AC to DC converter. According to Norazam bin Othman [5], inverter is an electrical power that converted a DC to AC. The inverter can be converted into any required voltage and frequency using switching, appropriate transformer and control unit. There is variable type of inverter has been used in industry. For example, multilevel inverter, square wave inverter, synchronous inverter and pulse width modulation inverter.

2.4 Five-phase inverter

This ventured is using of the five-phase inverter plays an important role to ensure these projects succeed. Five-phased is inverter work at line frequency, which the main output power. William R. Finley [6] stated that, the switch work at line frequency, so the switching loss is small and the efficiency of output power system is high. Five- phase full bridge inverter is used to improve system dynamic performance. Compared to traditional inverter circuit, higher efficiency can be achieved and at the same times harmonics will be low and voltage stress of power switches also can be reduce. Circuit can be control easily and also easy to modularized.

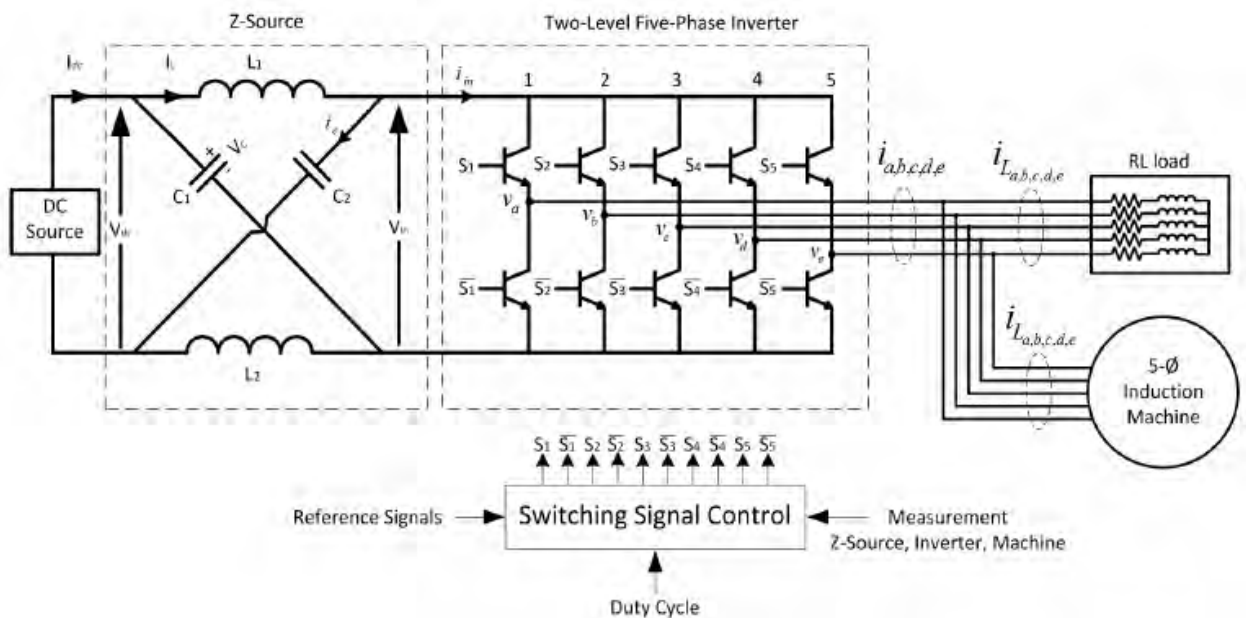


Figure 2.3: Five-phase inverter connected to five-phase induction motor with DC source and input

2.5 Gate drive

Gate drive is a power amplifier that accepts a low power input from a controller IC and produces a high-current drive input for IGBT or MOSFET. Muhammad Al-Amin

[7] stated that gate drives are an interface that accepts a low power input from a controller and produces a high current drive input for the gate power of high power IGBT.

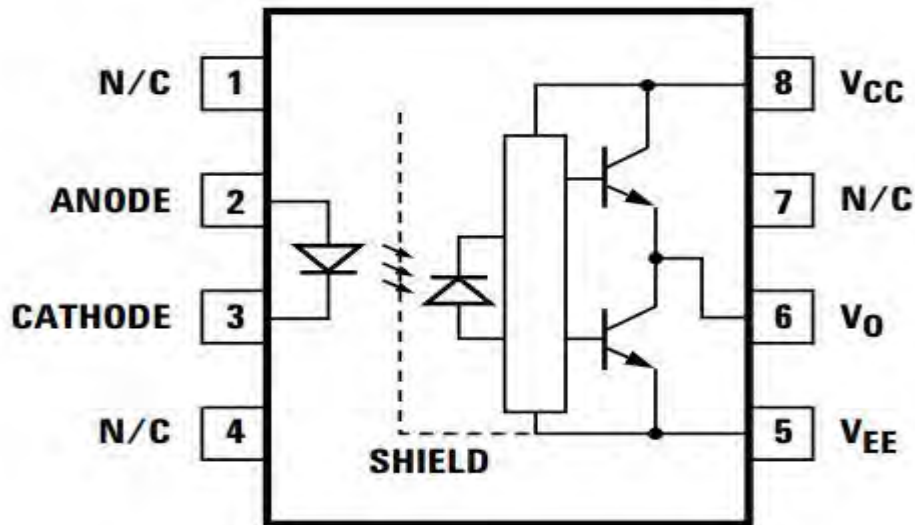


Figure 2.4: Opto-Coupler Gate Driver Example

2.6 Insulated Bipolar Junction Transistor (IGBT)

VISHAY [3] stated that, Insulated Gate Bipolar Transistor (IGBT) is a cross between Metal Oxide Semiconductor Field Effect Transistor (MOSFET) and a Bipolar Junction Transistor (BJT) since it combines the positive aspect of MOSFETs and BJTs. The IGBT has the fast switching capability of the MOSFET and is capable of handling the high current values typical of BJT. Moreover, IGBTs has a lower on-stage voltage drop and are capable of blocking higher voltage.

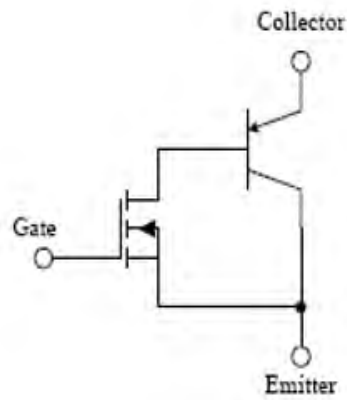


Figure 2.5: IGBT equivalent circuit

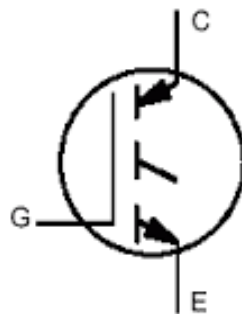


Figure 2.6: IGBT symbol

2.7 DSpace

DSpace is used as controller. Muhammad Al- Amin [7], DSpace is a set of cooperating Java web applications and utility program that maintain an asset store and an associated store. The web application provides interfaces for administration, deposit, ingest search and access. An item's exposed metadata is indexed for browsing and searching. Items are organized into collections of logically related material. The control algorithm has been implementing using DSpace board. The DSpace works on Matlab