SIMULATION OF ELECTRICAL FAULTS OF THREE PHASE INDUCTION MOTOR DRIVE SYSTEM

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A thesis submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Electrical Engineering (Power system)

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NOVEMBER 2009
DECLARATION

I declare that this thesis entitled “SIMULATION OF ELECTRICAL FAULTS OF THREE PHASE INDUCTION MOTOR DRIVE SYSTEM” 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 : Muhammad Alif Bin Mohd Nor
Date : 23 November 2009
ACKNOWLEDGEMENTS

Praise and glory to Allah S.W.T, God of all creation and greetings and salutations we bring forth to our Prophet Muhammad S.A.W for overseeing this final year project one and constantly guiding this project towards completion.

I’m as the author of this thesis wishes and express the greatest appreciation to Dr. Ahmed N Abd Alla as my supervisor of this final year project. Once, nobody believes the project will manage successfully, but with his dedication and guidance, the project is able to complete on time. Special thanks for him for the opportunity given and for the efforts towards the completion of the project.

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ABSTRACT

The title of this project is Simulation of electrical faults of three phase induction motor drive system. Induction motor or asynchronous motor is a type of alternating current motor where power is supplied to the rotor by means of electromagnetic induction. Induction motor is now the preferred choice for industrial motor due to their rugged construction, absence of brushes (which are required in most DC motors) and the ability to control the speed of motor. The faults that can occur in the three-phase induction motor and its driver can be divided into two parts; internal and external faults. The internal fault of induction motors account for the proportion almost more than 70% of induction motor failures. This project will cover and study a few type of internal and external faults, which is the stator inter-turn short circuit, unbalanced voltage supply and the single phase open circuit fault. The study of induction motor is crucial and important so that the lifespan of the motor can be prolonged. In this project MATLAB SIMULINK is used to simulate the induction motor faults and analyze the condition. The simulation file is then compiled along with a GUI to simplify the overall process and improves the user friendliness to users.
ABSTRAK

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DECLARATION</td>
<td>ii</td>
</tr>
<tr>
<td></td>
<td>DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td></td>
<td>ACKNOWLEDGMENTS</td>
<td>iv</td>
</tr>
<tr>
<td></td>
<td>ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td></td>
<td>ABSTRAK</td>
<td>vi</td>
</tr>
<tr>
<td></td>
<td>TABLE OF CONTENTS</td>
<td>vii</td>
</tr>
<tr>
<td></td>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>LIST OF SYMBOLS</td>
<td>xii</td>
</tr>
<tr>
<td></td>
<td>LIST OF APPENDIXES</td>
<td>xiv</td>
</tr>
</tbody>
</table>

I  INTRODUCTION
1.1  Chapter Overview  1
1.2  Background  2
1.3  Problem Statement  2
1.4  Objectives  3
1.5  Scopes of Study  3
1.6  Thesis Outline  4

II  LITERATURE REVIEW
2.1  Chapter Overview  6
2.2  Definition of Three Phase Induction Motor  7
      2.2.1  Stator  8
2.2.2 Rotor

2.3 Simulation of Electrical Faults for Induction Motor
   2.3.1 Stator Inter-turn Short Circuit
   2.3.2 Unbalanced Voltage Supply

2.4 MATLAB

2.5 Simulink

2.6 Block Set Power System
   2.6.1 Area of the Power System Block Set

III METHODOLOGY

3.1 Chapter Overview

3.2 Developing the MATLAB Program

3.3 Developing the Simulation Model
   3.3.1 Stator Inter-turn Short Circuit Model
   3.3.2 Unbalanced Voltage Supply Model
   3.3.3 Single-Phase Open Circuit Fault Model

3.4 Developing the GUI
   3.4.1 Main Window M-FILE Description
   3.4.2 Main Window M-FILE
      3.4.1.2 Description

IV RESULT & DISCUSSION

4.1 Chapter Overview

4.2 Simulation of Healthy State Motor

4.3 Simulation of Faulty State Motor
   4.3.1 Simulation for Inter-turn Short Circuit
   4.3.2 Simulation for Unbalanced Voltage Supply
   4.3.3 Simulation for Single Phase Open Circuit

4.4 Result Analysis
4.4.1 Inter-turn Short Circuit 64
4.4.2 Unbalanced voltage supply 65
4.4.3 Single phase open circuit 67

V CONCLUSION & RECOMMENDATION
5.1 Conclusion 71
5.2 Recommendations 72

REFERENCES 73

APPENDIX A 75
### LIST OF TABLES

<table>
<thead>
<tr>
<th>FIGURE NO.</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Description of the Motor Block Parameters</td>
<td>3</td>
</tr>
<tr>
<td>FIGURE NO.</td>
<td>TITLE</td>
<td>PAGE</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>2.1</td>
<td>Squirrel Cage Rotor</td>
<td>9</td>
</tr>
<tr>
<td>2.2</td>
<td>Wound Rotor</td>
<td>10</td>
</tr>
<tr>
<td>2.3</td>
<td>Balanced Voltage Supply</td>
<td>13</td>
</tr>
<tr>
<td>2.4</td>
<td>Unbalanced Voltage Supply</td>
<td>13</td>
</tr>
<tr>
<td>2.5</td>
<td>Library Browser for Simulink</td>
<td>19</td>
</tr>
<tr>
<td>2.6</td>
<td>Window for Model Using Functional Block</td>
<td>19</td>
</tr>
<tr>
<td>2.7</td>
<td>Library Browser for SimPower System</td>
<td>22</td>
</tr>
<tr>
<td>3.1</td>
<td>Work Flow of the Project</td>
<td>24</td>
</tr>
<tr>
<td>3.2</td>
<td>Opening M-file Window</td>
<td>25</td>
</tr>
<tr>
<td>3.3</td>
<td>New M-file Window</td>
<td>26</td>
</tr>
<tr>
<td>3.4</td>
<td>Three Phase Asynchronous Machine Model</td>
<td>27</td>
</tr>
<tr>
<td>3.5</td>
<td>Three Phase Induction Motor Model</td>
<td>28</td>
</tr>
<tr>
<td>3.6</td>
<td>Block Parameters of AC Voltage Source</td>
<td>28</td>
</tr>
<tr>
<td>3.7</td>
<td>Block Parameters of 1.5HP – 450V 50Hz – 1475rpm</td>
<td>29</td>
</tr>
<tr>
<td>3.8</td>
<td>Step Block</td>
<td>31</td>
</tr>
<tr>
<td>3.9</td>
<td>Three Phase Induction Motor model</td>
<td>32</td>
</tr>
<tr>
<td>3.10</td>
<td>Three Resistors before the Motor (healthy state)</td>
<td>33</td>
</tr>
<tr>
<td>3.11</td>
<td>One of the Resistor were Short Circuited</td>
<td>34</td>
</tr>
<tr>
<td>3.12</td>
<td>Voltage Setting for Healthy State Motor</td>
<td>35</td>
</tr>
<tr>
<td>3.13</td>
<td>Voltage Setting for Faulty State Motor</td>
<td>35</td>
</tr>
<tr>
<td>3.14</td>
<td>Voltage Supply for Healthy Model</td>
<td>36</td>
</tr>
<tr>
<td>3.15</td>
<td>Voltage Supply for Faulty State</td>
<td>37</td>
</tr>
<tr>
<td>3.16</td>
<td>GUI Window</td>
<td>38</td>
</tr>
</tbody>
</table>
3.17 Blank GUI Window 38
3.18 Example of Created GUI 40
3.19 Example of the Generated Program 40
3.20 Display the Program for Opening Function 41
3.21 Display the Opening Function Position 42
3.22 Display the Callback Function Line Position 43
4.1 Main GUI Window 46
4.2 Display the Confirm Action Window 46
4.3 Display the Healthy State Simulation Window 47
4.4 The Three Phase Voltages 48
4.5 The Three Phase Currents 48
4.6 Rotor Current 49
4.7 Stator Current 49
4.8 Electromagnetic Torque 50
4.9 Motor Speed 50
4.10 GUI for Faulty State 51
4.11 Simulation for Inter-turn Short Circuit 52
4.12 Three Phase Voltages 53
4.13 Three Phase Currents 53
4.14 Rotor Current 54
4.15 Stator Current 54
4.16 Electromagnetic Torque 55
4.17 Motor Speed 55
4.18 Simulation for Unbalanced Voltage Supply 56
4.19 The Three Phase Voltages 57
4.20 Three Phase Currents 57
4.21 Rotor Current 58
4.22 Stator Current 58
4.23 Electromagnetic Torque 59
4.24 Motor Speed 59
4.25 Simulation for Single Phase Open Circuit 60
4.26 The Three Phase Voltages 61
4.27 Three Phase Currents 61
4.28 Rotor Current 62
4.29 Stator Current 62
4.30 Electromagnetic Torque 63
4.31 Motor Speed 63
# LIST OF APPENDIX

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Program for GUI</td>
<td>77</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Chapter Overview

The title of this project is Simulation of electrical faults of three phase induction motor drive system. The faults that can occur in the three-phase induction motor and its driver can be divided into two parts; internal and external faults. The internal fault of induction motors account for the proportion almost more than 70% of induction motor failures. As example, stator inter-turn short circuit. For external faults, it happens at voltage supply, such as unbalance voltage supply and one phase open circuit.

From the faults that might occur, this project will analyze and simulate the electrical faults of three-phase induction motor and its drive. The modeling of the induction motor and the simulation of electrical faults in three phase induction motor drive will be done by using MATLAB tools.
This project can be divided into 3 different stages:

- Data extraction
- Develop Simulation
- Develop GUI

1.2 Background

Simulation technique has been proved to have many advantages rather than just doing a practical attempt. Especially for this project, the faults are intentionally being created to motor, to study the behavior of the motor when faulted. If we were doing this project with an actual motor, it will be a waste the motor gets damaged.

1.3 Problem Statement

The increased in demand has greatly improved the approach of fault detection in polyphase induction motor. Monitoring the motor condition in an early stage is crucial to detect any fault to eliminate the hazards of severe motor faults and preventing damage.
Nowadays simulation technique is implemented to improve traditional techniques, where the results can be obtained instantaneously after it analyzes the input data of the motor. In fact, some company use simulation technique while designing their new product.

In this project MATLAB SIMULINK is used to simulate the induction motor faults and analyze the condition.

### 1.4 Objectives

Simulation of electrical faults of three phase induction motor drive system is developed with the listed objectives below:

- To study the features for a various kind of faults of the induction motor and its drive system.
- To build an induction motor model and to simulate the internal and external faults using MATLAB tools.

### 1.5 Scopes of study

There are several scopes for the project:
• This project is mainly about a simulation of faults that may occur in three-phase induction motor and its drive.
• This project is use to detect faults in three phase induction motors only. It is the most popular poly phase induction motor in industry.
• The modeling and simulation will be done by using MATLAB tools.
• The type of faults which will be studied is limited to a few types of external and internal faults.

1.6 Thesis Outline

This thesis consists of five chapters. In the first chapter, this chapter discussed the overall idea of this project including objectives of project, problem statement, the scope of this project and summary of this thesis.

Chapter 2 discussed more on theory and literature review that have been done. It is well discusses about the MATLAB, basic concept of the fault in induction motor, SIMULINK and parameters related to this project.

Chapter 3 described briefly the methodology of the data extraction, simulation development and GUI development for this project. The figures, tables and extra information are aided into this chapter to be the benchmark thesis in development of Simulation of electrical faults of three phase induction motor drive system.
Chapter 4 presents a discussion of the implementation, result and analysis of the whole project. This chapter also explains the reasons of some failure.

Chapter 5 provides the conclusions of the project. There are also several suggestions that can be used for future implementation or upgrading for this project.
CHAPTER 2

LITERATURE REVIEW

2.1 Chapter overview

This chapter includes all the paper works and related research as well as the studies regards to this project. The chapter includes all important studies which have been done previously by other research work. The related works have been referred carefully since some of the knowledge and suggestions from the previous work can be implemented for this project.

Literature review was an ongoing process throughout the whole process of the project. It is very essential to refer to the variety of sources in order to gain more knowledge and skills to complete this project. These sources include reference books, thesis, journals and also the materials obtained from internet.
At the beginning of the project, the basic concept of fault in induction motor has been well acquired. In addition, the function of all the components used in this project such as basic operation of MATLAB Simulink, and so on was explored first before starting the project.

2.2 Definition of three phase induction motor

The AC induction motor is a rotating electric machine designed to operate from a three-phase source of alternating voltage. The stator is a classic three phase stator with the winding displaced by 120°. The most common type of induction motor has a squirrel cage rotor in which aluminum conductors or bars are shorted together at both ends of the rotor by cast aluminum end rings. When three currents flow through the three symmetrically placed windings, a sinusoidally distributed air gap flux generating the rotor current is produced. The interaction of the sinusoidally distributed air gap flux and induced rotor currents produces a torque on the rotor. The mechanical angular velocity of the rotor is lower than the angular velocity of the flux wave by so called slip velocity. [1]

AC induction motors are the most common motors used in industrial motion control systems, as well as in main powered home appliances. Simple and rugged design, low-cost, low maintenance and direct connection to an AC power source are the main advantages of AC induction motors. [6]
The induction motor essentially consists of two parts:

1. Stator
2. Rotor

The supply is connected to the stator and the rotor received power by induction caused by the stator rotating flux, hence the motor obtains its name – induction motor. [2]

2.2.1 Stator

The stator consists of a cylindrical laminated & slotted core placed in a frame of rolled or cast steel. The frame provides mechanical protection and carries the terminal box and the end covers with bearings. In the slots of a 3-phase winding of insulated copper wire is distributed which can be wound for 2, 4, 6 etc. poles. The rotor consists of a laminated and slotted core tightly pressed on the shaft [3]

The stator is made up of several thin laminations of aluminum or cast iron. They are punched and clamped together to form a hollow cylinder (stator core) with slots as shown in Figure 1. Coils of insulated wires are inserted into these slots. Each grouping of coils, together with the core it surrounds, forms an electromagnet (a pair of poles) on the application of AC supply. The number of poles of an AC induction motor depends on the internal connection of the stator windings. The stator windings are connected directly to the power source. Internally they are connected in such a way, that on applying AC supply, a rotating magnetic field is created. [6]
2.2.2 Rotor

The rotor consists of a laminated and slotted core tightly pressed on the shaft. There are two general types of rotors:

1. The squirrel-cage rotor
2. The wound (or slip ring) rotor

![Figure 2.1: Squirrel Cage Rotor](image)

In the squirrel-cage rotor, the rotor winding consists of single copper or aluminum bars placed in the slots and short-circuited by end-rings on both sides of the rotor. [3]
The field windings in the stator of an induction motor set up a rotating magnetic field around the rotor. The relative motion between this field and the rotation of the rotor induces electric current in the conductive bars. In turn these currents lengthwise in the conductors react with the magnetic field of the motor to produce force acting at a tangent to the rotor, resulting in torque to turn the shaft. In effect the rotor is carried around with the magnetic field but at a slightly slower rate of rotation. The difference in speed is called “slip” and increases with load. [4]

![Diagram of stator, rotor, and start resistance](image)

**Figure 2.2:** Wound rotor

A wound rotor induction motor has a stator like the squirrel cage induction motor, but a rotor with insulated windings brought out via slip rings and brushes. However, no power is applied to the slip rings. Their sole purpose is to allow resistance to be placed in series with the rotor windings while starting. This resistance is shorted out once the motor is started to make the rotor look electrically like the squirrel cage counterpart. [5]
2.3 Simulation of electrical faults for induction motor

Computer simulation of electric motor operation is particularly useful for gaining an insight into their dynamic behavior and electro-mechanical interaction. A suitable model enables motor faults to be simulated and the change in corresponding parameters to be predicted without physical experimentation. [8]

Modeling of induction motors with shorted turns is the first step in the design of turn fault detection systems. Simulation of transient and steady state behavior of motors with these models enable correct evaluation of the measured data by diagnostics techniques. [7]

This paper will cover few types of electrical faults. The electrical faults can be divided into two parts, the external and internal faults. An external fault is a fault that occurs outside the motor, and the internal fault is a fault that occurs inside the motor. For the external fault, we will cover the unbalance voltage supply and one-phase open circuit fault. For the internal fault we will cover the stator inter-turn short circuit.

2.3.1 Stator inter-turn short circuit

The stator winding consists of coils of insulated copper wire placed in the stator slots. Stator winding faults are often caused by insulation failure between two adjacent turns in a coil. This is called a turn-to-turn fault or shorted turn. The resultant induced currents produce extra heating and cause an imbalance in the magnetic field in the machine. If undetected, the local heating will cause further