AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

ELECTRICAL POWER & MACHINES DEPARTMENT

Post-Fault Speed Sensor-Less Operation of Six-Phase Induction Motors

A thesis submitted for partial fulfillment of the requirements for the M.Sc. degree in Electrical Engineering

(Electrical Power & Machines Department)

Submitted by:

Islam Mohamed Soliman

Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Department)

Faculty of Engineering, Ain shams university, 2011

Supervised By

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Cairo - (2018)

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Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements of Master of Science degree in Electrical Engineering.

The included work in this thesis has been carried out by the author at the department of electrical power and machines, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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Publications

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Thesis Summary

Recently, high power drive applications imposed the researchers to investigate a several methods for electric power supply segmentation in order to respect the prescribed converter power limits. Multiphase machines are engaged in fierce competition with others conventional three phase machines especially in the industrial applications due to harmonics reduction, greater fault tolerance with better redundancy and performance. In addition, reliability is the main concern in the most of industrial applications. Therefore, studying the electrical drives behaviour during a fault condition is the key to ensure system sincerity.

This study introduces a post-fault speed estimator for asymmetrical six-phase (6-ph) induction machines (IM) under single open phase condition. The proposed technique is based on Kalman Filter (KF) estimator. The multiphase machine model scheme is associated with proportional integral (PI) speed control. Also, the indirect field-oriented control (IFOC) is intended to be used and followed by a hysteresis current controller (HCC). Different operating conditions have been carried out to investigate the estimator fidelity. The simulation study is performed using MATLAB / SIMULINK platform. The simulations results show a promising performance of the proposed speed estimator.

Keywords:

Asymmetric six phases, multiphase machine, Kalman filter, sensorless operation, speed estimation

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List of Abbreviations

AC	Alternating Current
ANFIS	Adaptive Neuro- Fuzzy Inference
ANN	Artificial Neural Network
DFOC	Direct Field Oriented Control
DTC	Direct Torque Control
DC	Direct Current
FIS	Fuzzy Inference System
FO	Field Oriented
FOC	Field Oriented Control
FLC	Fuzzy Logic Control
FOPI	Fractional Order Proportional Integral
IFOC	Indirect Field Oriented Control
IM	Induction Motor
IRFOC	Indirect Rotor-Field-Oriented Control
HCC	Hysteresis Current Controller
KF	Kalman Filter
MRAS	Model Reference Adaptive System
PI	Proportional Integral
PWM	Pulse-Width Modulation
RMS	Root Mean Square
SPWM	Sinusoidal Pulse Width Modulation
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
VSI	Voltage Source Inverter

1 INTRODUCTION

All Electrical motors are a vital part for any electrical system, especially in the industrial applications. Many developments are carried out to enhance motor operation, control and protection.AC induction motor is the most common and practical motor among the other types of the electrical motors. Also, it can be considered as the best choice in terms of robustness, lower cost, minimal maintenance and lower weight at a relatively wide power range.

Multiphase AC induction motor was released in the middle of 1990s due to the need of extra high power applications, including railway traction industry, wind generation and electric ship propulsion, etc.,[1-5]

Multiphase winding layout can be broadly classified into symmetrical or asymmetrical winding layouts. The phase belt angle between two adjacent phases is known to be the main factor to identify the machine winding scheme [6, 7].

Reliability is the main concern in the most of industrial applications. Therefore, studying the electrical drives behavior during a fault condition is the key to ensure the system sincerity [8, 9]. So far, vector control is usually the basic technique used for induction machine control [10, 11]. Also, speed sensor is commonly required for the indirect field oriented control (IFOC) in order to measure the rotor position. Moreover, the flux sensors are expensive and unreliable [12].

Thus, several methods are presented to eliminate the speed sensor for the six-phase induction motor. The fuzzy logic control was shown insensitive to parameter variations but has a limited adaptable range [13-16]. Another technique used is the model reference adaptive system (MRAS) which is one of the famous methods used thanks to its high robustness and fast response Nevertheless, this method suffers from noise and disturbances affecting the system [17]. Also, high control efforts and chattering are the main problems for sliding mode observer method [18].