AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Engineering

Impact of Wind Farm Disturbance on Power System Performance

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science In Electrical Engineering

(Electrical Power and Machines Engineering)

By

MAHMOUD MAGED ABDEL AZEEM ELSHARKAWY

Bachelor of Science In Electrical Engineering

(Electrical Power and Machines Engineering)

Faculty of Engineering, Ain Shams University, 2013

Supervised By

Prof. Dr. ALMOATAZ YOUSSEF ABDELAZIZ

Dr. MAHMOUD ABDALLAH ATTIA

Cairo – July 2019

Ain Shams University
Faculty of Engineering
Electrical power and Machines Department

Impact of Wind Farm Disturbance on Power System Performance

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science of Electrical Engineering

By

Mahmoud Maged Abdel Azeem Elsharkawy

B.Sc. Electrical Engineering, Ain Shams University, 2013

Examiners Committee

Title, Name & Affiliation	Signature
Prof. Dr. / **Ashraf Mohamed Hemeida** Faculty of Energy Engineering, Aswan University	……..
Prof. Dr. / **Hany Mohamed Hasanien** Faculty of Engineering, Ain Shams University	……..
Prof. Dr. / **Almoataz Youssef Abdelaziz** Faculty of Engineering, Ain Shams University	……..

Date: (/ / 2019)

Researcher Data

Name	: Mahmoud Maged Abdel Azeem Elsharkawy
Date of birth	: 1/12/1991
Place of birth	: Cairo
Academic Degree	: B.Sc. in Electrical Engineering.
Field of Specialization	: Electrical Power and Machines
University issued the degree	: Faculty of Engineering, Ain-Shams University.
Date of issued degree	: 2013
Current job	: Electrical design engineer at Misr Consult, Egypt

Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Mahmoud Maged El Sharkawy

Signature

……..…….

Date:28 July 2019

Acknowledgment

First of all, I would like to thank Allah “God” for providing me with health and patience to finish this dissertation.

I would like to thank a lot of people for their support toward the completion of this degree. Specifically Prof. **Dr. Almoataz Youssef Abdelaziz**. For his expert advices, guidance and encouragement throughout my study.

I wish to express my sincere gratitude to **Dr. Mahmoud Abdullah.** For his great help in the supervision of this thesis. He always helped me and gets a solution whenever I ran into a trouble spot or had a scientific question about my work

Though away from them during the completion of this degree, I would like to send my deepest appreciations and thanks to my family for their support and to whom this dissertation is dedicated.

I am grateful to all of my friends who supported me and believed in me during the study. I would especially like to thank Eng/ Sameh Karem and Dr/ Mahmoud Omar.

Mahmoud Maged El-Sharkawy

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Symbols and abbreviations

$\boldsymbol{A}$	Area swept by wind turbines
$\boldsymbol{C_p}$	Power coefficient.
DFIG	Doubly Fed Induction Generator.
FSWT	Fixed Speed Wind Turbine
GSC	Grid Side Converter
HSA	Harmony Search Algorithm
VSWT	Variable Speed Wind Turbine
$\mathbf{K_I}$	Integral control gain.
$\mathbf{K_P}$	Proportional control gain.
$\mathbf{K_d}$	Deferential control gain.
$\boldsymbol{m}$	Mass of air.
P	Proportional controller.
PI	Proportional- integral controller.
PID	Proportional-integral-Deferential controller.
PQ	Power quality.
PCC	Point of Common Coupling
RSC	Rotor Side Converter
WECS	Wind Energy Conversion System.
WOA	Whale Optimization Algorithm
$\boldsymbol{\rho}$	Air density.
$\boldsymbol{\lambda}$	Tip speed ratio.
$\boldsymbol{\beta}$	Pitch angle.
$\boldsymbol{\Omega}$	Rotational speed of the turbine.

ABSTRACT

Scarcity in fossil fuel reserves and their negative impact on environment have urge society to look at alternate renewable energy sources to feed this Continuous growing of energy demand. Among the various renewable energy sources, researchers have proved wind energy as the most effective solution over other renewables for many reasons. It`s considered as a green energy source. It needs low running cost. Also, it allows more than 90% of used land to be used for cultivation. Since wind energy has a special nature as it depends on variable climatic and weather conditions changes, wind speed variability problem introduced itself as one of the most crucial challenges for wind energy captured from wind farms.

In this thesis, the theory of wind energy generation and wind turbines types are discussed showing the main features of each type. Then, thesis will focus on the Doubly Fed Induction Generator (DFIG) features and its preference over other generators types. After that, the thesis discusses the main grid code requirements. Also, it illustrates the most important challenges facing wind farm`s operator to comply with grid code requirements.

In final section, thesis will focus on the wind speed variability challenge. It enumerates the most popular solutions to overcome these struggles focusing on Pitch Angle Control technique. Thesis will use the Harmony Search Algorithm to optimize the different controller's gains at different operation conditions. Then, thesis will compare the Pitch Angle response in case of optimization based on both the Harmony Search Algorithm (HSA) and the Whale Optimization Algorithm (WOA) in an arbitrary season of the year. Finally, the thesis enhances the system performance under faulty conditions. Wind farm model under study will be modeled in MATLAB/Simulink, with the use of DFIG.

The major contributions of this thesis are:

(i) Searching for the most reasonable control method in regulating wind speed variability challenge on power system performance, (ii) Application of both HSA and WOA techniques in controllers' gains tuning.

Keywords

Power quality, Pitch Angle Control, Grid Code Requirements, Doubly Fed Induction Generator, Wind Energy, Wind Speed Variability, Harmony Search Algorithm and Whale Optimization Algorithm.