



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

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# 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.

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# List of Symbols and abbreviations

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

# ABSTRACT

Scarcity in fossil fuel reserves and their negative impact on environment have urged 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.