



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم



MONA MAGHRABY



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التوثيق الإلكتروني والميكروفيلم



شبكة المعلومات الجامعية التوثيق الإلكتروني والميكروفيلم



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جامعة عين شمس التوثيق الإلكتروني والميكروفيلم

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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

Ain Shams University
Faculty of Engineering
Electrical power and Machines Dept.

**OPERATION AND CONTROL OF OFFSHORE
WIND FARM CONNECTED TO HIGH VOLTAGE
DIRECT CURRENT TRANSMISSION SYSTEMS**

Ph.D. Thesis
By

Eng. Hassan Youssef Mahmoud

Submitted in partial fulfillment of the Requirements for
the Ph.D Degree in Electrical Engineering

Supervised By

Prof. Dr. Almoataz Youssef Abdelaziz

Professor - Electrical Power and Machines Department
Faculty of Engineering, Ain Shams University

Prof. Dr. Hany Mohamed Hasanien

Professor-Electrical Power and Machines Department
Faculty of Engineering, Ain Shams University

Prof. Dr. Ahmad Hussien Tawfeek Besheer

Professor-Environmental Studies and Research Institute
Sadat City University

Cairo
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Approval Sheet

For The thesis:

OPERATION AND CONTROL OF OFFSHORE WIND FARM CONNECTED TO HIGH VOLTAGE DIRECT CURRENT TRANSMISSION SYSTEMS

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Approved by

Name

Signature

Prof. Dr. Almoataz Youssef Abdelaziz

A.Y. Abdelaziz

Prof. Dr. Hany Mohamed Hasanien

H.M. Hasanien

Prof. Dr. Ahmad Hussien Tawfeek Besheer

A.H. Besheer

Date: / / 2020

Examiners Committee

The thesis:

OPERATION AND CONTROL OF OFFSHORE WIND FARM CONNECTED TO HIGH VOLTAGE DIRECT CURRENT TRANSMISSION SYSTEMS

Presented by

Eng. Hassan Youssef Mahmoud

Submitted in partial fulfillment of the requirements for the
Ph.D degree in electrical engineering

Name, title and affiliation

Signature

- 1. Prof. Dr. Elsaid Abdelaziz Osman**
Electrical Power System
Faculty of Engineering
Al-Azhar University
- 2. Prof. Dr. Said Fouad Mekhamer**
Electrical Power and Machines Department
Faculty of Engineering
Ain Shams University
- 3. Prof. Dr. Almoataz Youssef Abdelaziz**
Electrical Power and Machines Department
Faculty of Engineering
Ain Shams University
- 4. Prof. Dr. Hany Mohamed Hasanien**
Electrical Power and Machines Department
Faculty of Engineering
Ain Shams University

S. A. Osman

Said Fouad Mekhamer

A. Y. Abdelaziz

Hany Mohamed Hasanien

Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for Ph.D degree in Electrical Engineering.

The included work in this thesis has been carried out by the author at the Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

Name : Hassan Youssef Mahmoud

Signature :

Date : / / 2020

To

My Parents, my wife, and my children.

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ABSTRACT

Offshore Wind Farm (OWF) has been gained a wide acceptance nowadays as it is deemed one of the extremely used renewable energy source owing to its wide utilization all over the world and the major unexploited wind energy as well as better wind circumstances. One of the main parts in this system is the controller itself, so the appropriate selection of effective controllers is considered important and necessary.

The significant problem facing the renewable resources and impedes their spread and widespread use of them to support the unified network is their control structure. This control structure is very complicated and consumes a long time. So, many researches have been directed towards the new control algorithms and techniques to define the main controllers parameters. Among the most important and most frequently used controllers in OWF connected to High Voltage Direct Current (HVDC) transmission systems and in almost of practical experiments and in industries applications are Proportional-Integral (PI) and Fuzzy Inference System (FIS) controllers. FIS is commonly utilised in inverter control stations in many applications due to its appropriate for use in a nonlinear system and involves no mathematical modelling. Thus, FIS is chosen to improve the performance of the converter/inverter stations in the studied model.

The main contribution of this thesis is to present an optimal design process for the controller's parameters utilized in the voltage source converter (VSC) of OWF interconnecting with a HVDC transmission

system by using a meta-heuristic algorithms for enhancing the performance of the system under study.

The proposed algorithms are used to design and tune the PI controllers' parameters to improve the performance of overall system. It shall be mentioned that, these parameters are usually hard to obtain owing to the high level of embedded nonlinearity in such energy systems. The performance of such optimally designed PI controllers is presented during network disturbances due to the transient conditions.

On the other hand and related to FIS controller, optimization technique can be used to fine tune the FIS controllers' parameters (such as the scaling gain factors and the membership functions for each FIS input/output), to overcome the design constraints on FIS, to handle the complexity of the studied system, and finally to optimise the FIS behaviour.

The analytical and statistical solutions acquired from the offered algorithms are compared with other meta-heuristics approaches such as genetic algorithms to examine the efficiencies of the design parameters in case of symmetrical or asymmetrical faulty conditions happened at grid side. It is spotted that the offered algorithms have promising features and better-damped performance compared to genetic algorithm especially to fulfill the Fault Ride Through (FRT) capabilities of OWF connected with the grid via HVDC transmission system.

The new algorithms were extensively examined and tested using the MATLAB/Simulink simulation package and were confirmed to be reliable

as demonstrated in the simulated results. With the proposed optimization algorithms, FRT capability of Permanent Magnet Synchronous Generator (PMSG) based Variable Speed Wind Turbine (VSWT) and connected with HVDC transmission can be improved.

For the sake of examining the realistic stability of the proposed algorithm, real wind speed pattern has been captured from Egypt wind farm at Zafarrana and is deemed in this study.

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