بسم الله الرحمن الرحيم

MONA MAGHRABY

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

MONA MAGHRABY

شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Department

Performance Enhancement of Electrical Power Systems with High Penetration Level of Wind Energy Resources

By

Eng. Mahrous EL- Azab Abdel Maksoud Badawi

M.Sc. in Electrical Engineering, Cairo University, 2004

A Thesis Submitted in Partial Fulfillment of the Requirements of the Degree of Doctor of Philosophy in Electrical Engineering (Electrical Power and Machines Department)

Supervised by

Prof. Dr.: Hossam Eldin Abdallah Talaat

Prof. Dr.: Said Fouad Mekhamer

Assoc. Prof. Dr.: Walid Atef Omran

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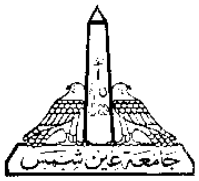

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Supervision Committee

Name and Affiliation	**Signature**
Prof. Dr. / Hossam Eldin Abdallah Talaat Electrical Power and Machines Department, Faculty of Engineering Ain Shams University	……
Prof. Dr. / Said Fouad Mekhamer Electrical Power and Machines Department, Faculty of Engineering Ain Shams University	……
Assoc. Prof. Dr. / Walid Atef Omran Faculty of Engineering & Materials Science German University in Cairo	……

Date: 04/09/2021

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Examiners' Committee

Name and Affiliation	**Signature**
Prof. Dr./ Essam El-Din Abo El-Zahab Electrical Power and Machines Department, Faculty of Engineering, Cairo University	…….
Prof. Dr. /Abdel-aal Hassan Ismail Mantawy Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University	…….
Prof. Dr. / Hossam Eldin Abdallah Talaat Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University	…….
Prof. Dr./ Said Fouad Mekhamer Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University	…….

Date: 04/09/2021

Statement

This thesis is submitted as a partial fulfillment of Doctor of Philosophy 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.

Name: Mahrous EL-Azab Abdel Maksoud

Signature: ……..……

Date: ……...……..

➲ Contact Information

Address	:	29 El-Salam St. Haram, Giza, Egypt
Mobile	:	(+2) 01119005373
E-Mail	:	mahrousazab@yahoo.com

Date:04 September 2021

Researcher Data

Name	: Mahrous EL-Azab Abdel Maksoud Badawi
Date of birth	: 23 May 1971
Place of birth	: Zagazig, Al Sharqia, Egypt
Last academic degree	: M.Sc. in Electrical Engineering
Field of specialization	: Electrical power and Machines
University issued the degree	: Faculty of Engineering, Cairo University
Date of issued degree	: 2004
Current job	: Electrical Engineer at Osman Group Company

Abstract

In recent years the limitations of fossil fuel resources and environmental pollution has created great tendency towards the use of renewable energy resources. However, the integration of high penetration levels of renewable energy resources along with the increased load demand and aging of the transmission network will push these networks to work closer to their operating limits. As a result, transmission congestion is a growing concern that could limit integration of new renewable energy projects. With large-scale wind power integration, the system operators need to exploit more flexibility in the planning and operation of the power system to maximize the utilization of existing transmission networks. This can be achieved by using cost-effective transmission technologies, thereby taking full advantage of the inherent flexibility of the system. In this thesis, we focus on implementing two different approaches that can lead to increasing the penetration level of wind power while managing possible congestions in the transmission network. Moreover, we propose using the Dynamic Line Ratings (DLRs) technology that could potentially increase the capacity of existing transmission networks and avoid unrealistic congestions.

The first approach presents a probabilistic multi-objective optimization approach to obtain the optimal sizes and locations of static var compensators (SVCs) and thyristor-controlled series compensators (TCSCs) in a power transmission network with high penetration level of wind power. The objective of the problem is to maximize the system loadability while minimizing the network power losses and the installation cost of the FACTS devices. The optimization problem is solved using the multi-objective teaching-learning based optimization (MO-TLBO) algorithm to find the best locations and ratings for the FACTS devices. In this approach, the uncertainties associated with wind power generation and the correlated load

demand are considered. The uncertainties are handled using the points estimation method (2PEM+1). Moreover, the DLRs of the transmission lines are considered in this approach. Based on the simulation results, it is found that the proposed approach successfully achieves a compromise of the desired objectives, and hence, is able to manage the possible congestions in the network due to the increased penetration levels of wind power.

The second approach, investigates the possibility of changing the network topology using the Optimal Transmission Switching (OTS) strategy while considering the DLR in the congestion management. In this approach, a probabilistic multi-objective based congestion management procedure is proposed using OTS strategies considering the maximization of system reliability and minimization of the total generation cost. Additionally, the prevention of islanding is considered to ensure the feasibility of transmission switching status. The uncertainties associated with load demand and wind power are considered. The formulated optimization problem is solved using the multi-objective teacher learning based optimization (MOTLBO) algorithm. The results in this approach show that a better utilization of the transmission capacity can be achieved through network topology reconfiguration, and DLR technology and allows for higher wind power integration.

Key Words: wind energy, uncertainty, FACTS devices, optimal power flow, reliability, islanding, network topology optimization, optimal transmission switching, dynamic line rating, multi-objective optimization, MOTLBO, points estimation method.

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