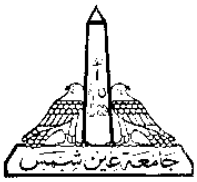


AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electrical Power and Machines Engineering

Reliable Smart Transformer Integration in Micro Grids

A Thesis submitted in partial fulfilment of the requirements of the degree of
Doctor of Philosophy in Electrical Engineering
(Electrical Power and Machines Engineering)

by

Ibrahem Mohamed Ahmed Mahmoud

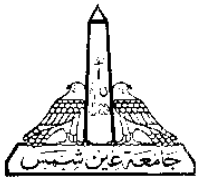
Master in Renewable Energy Engineering
Faculty of Engineering, The British University in Egypt

Supervised By

Prof. Tarek Saad Abdel-Salam

Assoc. Prof. Rania Abdel-Wahed Swief

Cairo - (2020)



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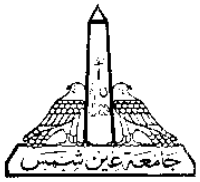

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Statement

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.

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Abstract

The proliferation and ever-growing of the renewable energy sources and the appearance of recently upgradable loads as electric vehicles (EV) and its charging stations may cause some of the operational and technical challenges for the distribution systems and may occur extremist variation in the traditional interpretation of the distribution network. Although the numerous pros due to the improvement of the distributed generations spatially in the renewable energy field, one of the main challenges that consider as constrain to the distribution network is evolving the possibility to owe a bidirectional power flow which occurred by varying load profile and generation profile. Therefore, the uprising utilization of the distributed generation may affect on the performance of the power system and causes many problems like overvoltage and Under voltage, overloads, power losses. Therefore, the utilization of the smart grid and microgrid is become widely used in modern networks. The smart grid has many features as it enhances the network efficiency, decreasing the power losses in addition to less cost than the traditional one and the smart grid able to be monitored and controlled. One of the important parts of the smart-grid component is the smart transformer.

In this thesis, the smart transformer impact as an important part of the smart grid components is investigated. The smart transformer is permitting a bidirectional of the power flow. The smart transformer works to regulate the voltage and send feedback about the power supply of the grid to the remote administrators. By following a criterion called the voltage optimization, smart transformers can provide the exact amount of the required power. The work in this thesis is intended to extend the application of a smart transformer on a radial distribution system. Also, in this thesis, an updated algorithm on the backward/forward power flow is introduced. The so-called direct approach power flow is employed and analyzed. In addition, the work is focused on integrating a smart transformer to the network and solving the updating network also using the direct approach load flow. The solution of the smart transformer using the direct approach power flow method is quite straightforward. This model is applied on different radial distribution systems which are the IEEE-33 and IEEE- 69 bus system as a case study.

Minimization power losses in the distribution systems is a must as these networks suffer from a huge amount of power losses. The minimization of power losses is done by using distributed generations as a solution to this problem. Distributed generation (DG) considers a solution for such a problem, in addition, the location of the DG enhances the voltage profile. That makes the researchers in the last years focus on exploring other aspects of power systems like reliability stability and protection. So, the appropriate amount of the power is dedicated through different optimization technique which is the Genetic Algorithm (GA) and the Particle Swarm Optimization (PSO). The optimization techniques are utilized for detecting the best location of the smart transformer and the best phase shift angle of the transformer to achieve the best minimization of the power losses. In addition, it is investigated to find and validate the optimum solution which is resultant from the applied optimization techniques.

In addition, power system reliability is considered in this thesis. the observation from recently published researches that the widely used reliability indices are the energy not supplied (ENS), average energy not Supplied (AENS), system average interruption duration index (SAIDI), The Customer Average Interruption Duration Index (CAIDI) and system average interruption frequency index (SAIFI) in power system.

The obtained results proved the effectiveness and the validation of the applied optimization techniques. The results show that the two proposed algorithms give the exact same results. The simulation results using MATLAB programming showed that the proposed algorithms are able to maximize the power losses reduction percentage and improve the voltage profile of the network.

Keywords:
Smart Transformer, Phase Shift Angle , Distribution System, Smart grid, Direct Approach, Power Losses, Particle Swarm Optimization, Genetic Algorithm, Reliability Indices.

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Thank you.
Ibrahem Mohamed

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