VOLTAGE STABILITY ENHANCEMENT IN DISTRIBUTION NETWORKS WITH DISTRIBUTED GENERATIONS

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Dedication to my beloved father, Ishak Bin Ahmad, my beloved mother, Che Sum Binti Abdul Aziz and my lovely wife Nurzarina Binti Abu Bakar whom support me, physically, mentally and emotionally, throughout my Master's study.

For my siblings and friends, appreciate your encouragement and help.
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ABSTRACT

The increasing energy demands are stressing the generation and transmission capabilities of the power system. Generally, Distributed generation (DG) which been located in distribution systems, has the ability to meet some of the growing energy demands. However, unplanned application of individual distributed generators might cause other technical problems. Recently, more attention has been focus for systematic planning and to optimize the performance of distribution networks with an objective to reduce losses and provide good quality supply to the consumers. The present trend in planning distribution systems is to employ distributed generators preferably at high load density buses. In this project, Fuzzy logic approach is employed to obtain optimal location of DG and its size by an analytical method to minimize losses and improve voltage regulation in distribution systems. To show the effectiveness of the proposed DG placement method, this approach is implemented in an IEEE-14 Bus System using PSAT which is a MATLAB toolbox environment. From the results obtained using the proposed method it is observed that even with a lower size DG there is a higher percentage of loss reduction and a better voltage profile.

ABSTRAK

Peningkatan permintaan tenaga yang semakin meningkat telah memberikan tekanan terhadap keupayaan penjanaan dan penghantaran sistem kuasa. Penjanaan teragih (DG), yang secara amnya terletak di dalam sistem pengedaran, mempunyai keupayaan untuk memenuhi sebahagian daripada permintaan tenaga yang semakin meningkat. Walau bagaimanapun, pemasangan penjana teragih yang tidak dirancang mungkin akan menyebabkan masalah teknikal lain. Dewasa ini, banyak perhatian telah diberi untuk perancangan sistematik dan mengoptimumkan prestasi rangkaian pembahagian dengan tujuan mengurangkan kerugian dan menyediakan bekalan yang berkualiti kepada pengguna. Di masa kini, perancangan sistem pembahagian mengambilkira peranan penjana teragih pada beban yang berketumpatan tinggi. Pendekatan *Fuzzy Logic* diambil kira di dalam projek ini untuk mendapatkan lokasi optimum DG dan saiz dengan kaedah analisis untuk meminimumkan kehilangan kuasa dan memperbaiki pengaturan voltan dalam sistem pengagihan. Untuk menunjukkan keberkesanan kaedah penempatan DG yang dicadangkan itu, pendekatan ini dilaksanakan dalam Sistem Bas IEEE-14 menggunakan PSAT iaitu persekitaran toolbox MATLAB. Daripada keputusan yang diperolehi menggunakan kaedah yang dicadangkan didapati bahawa walaupun dengan saiz yang lebih rendah DG terdapat peratusan yang lebih tinggi daripada pengurangan kehilangan kuasa dan profil voltan yang lebih baik.

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INTRODUCTION

1.1 Project Background

The most challenge for power system engineers is to meet the ever increasing load demand with available generating capacities. Developing more additional generation capacity involves huge capital investments and hence it is imperative to operate the existing power system network with optimal utilization. This requires systematic methods of planning and should employ suitable control strategies to reduce the energy losses and to improve the power quality supplied to the consumers. The major components of a power system are Generating stations interconnected through high voltage transmission network and low voltage distribution network to the different points of utilization of electrical energy. The planning, design and operation of Generating systems and Transmission systems has been systematically analysed and suitable control strategies to optimize the performance have been put into practice. Especially in the systematic planning and design of distribution systems much attention is needed to improve the power quality supplied to the consumers.

Normally, the distribution system is sectionalized into Primary distribution network and Secondary distribution network [1]. A primary distribution network delivers power at higher than utilization voltages from the substation to the point where the voltages are further stepped down to the value at which the energy is utilized by the consumers. The secondary distribution network supplies power to the consumer premises at levels of utilization voltages. Based on the scheme of connection the primary distribution system may be a Radial distribution system or a Mesh system.

Most of the primary distribution systems are designed as radial distribution systems having exclusively one path between consumer and substation and if it is interrupted results in complete outage of power to the consumers. The main advantages of radial system are simplicity of analysis, simpler protection schemes, lower cost and easy predictability of performance.

A mesh system has two paths between substation and every consumer and it is more complicated in design and requires complex protection schemes which involves higher investment than in radial systems. The radial distribution systems are inherently less reliable than mesh systems but reliability can be improved with good design. In current situation, many researchers have suggested different strategies to effectively reduce the energy losses in the distribution network and maintain a good voltage profile at various buses in the network. Basically, various reactive compensation methods to reduce the reactive component of currents in the feeders thereby reduce the energy losses, kVA demand on the feeders and improve the voltage profile in the distribution system have been suggested by many researchers. The different methods suggested to optimize the performance of distribution system are optimal sizing and placement of Capacitors, reconductoring of feeders, employing Voltage Regulators at proper locations and Distributed Generators at suitable locations. The above strategies has been investigated to improve the overall performance of the distribution network, an efficient and robust load flow technique suitable for distribution systems is required.

The conventional load flow methods used for power system networks such as Newton – Raphson and Fast Decoupled load flow methods cannot provide solution for the distribution system because of high R/X ratio (ill conditioned systems). Hence an efficient load flow method of solution for solving distribution systems with balanced and unbalanced load configuration is required. To ensure good quality of supply to consumers it is necessary to limit the voltage drops and reduce power losses by proper choice of compensation techniques such as capacitor placement, voltage regulators, distributed generators, network reconfiguration and grading of conductors.

In planning distribution systems, the present trend is installation of distributed (or local) generators other than central generating stations closer to consumer premises preferably at high load density locations. Distributed Generators (DGs) are small modular resources such as photo voltaic cells, fuel cells, wind generators, solar cells. Such locally distributed generation has several merits from the point of environmental restrictions and location limitations.

The main reason for increasingly wide spread deployment of DG can be summarized as follows:

i. DG units are closer to customers so that Transmission and Distribution costs are reduced or avoided.

ii. Reduced line losses

iii. Power quality improvement as well as voltage profile improvement

iv. Improvement of system reliability and security

v. It is easier to find location for small generators.

vi. By increasing overall efficiency fuel cost will be reduce

vii. Usually DG plants require minimal installation times and the investment risk is low.

viii. DG plants yield fairly good efficiencies especially in cogeneration and in combined cycles (larger plants).

ix. The liberalization of the electricity market contributes to create opportunities for new utilities in the power generation sector.

x. The costs of Transmission and Distribution costs have increased while costs of DG have reduced and hence, the overall costs are reduced with the installation of DGs.

In fact, the planning of distribution systems is not to support installations of Distributed Generators at various locations. However, installation of DGs on one hand improves the overall performance of the distribution system where as on the other hand poses new problems. Their grid connections, pricing and change in protection schemes are some problems with DGs. To achieve maximum benefit from installation of DGs, it is formulated as an optimization problem to locate and fix the size of DGs with the constraint on total injection of installed DGs in a radial distribution system.

Recently, a large number of Artificial Intelligent techniques have been employed in power systems. Nowadays, the problem of distribution systems efficiently can be solved by using Fuzzy Logic. Fuzzy logic is a powerful tool in meeting challenging problems in power systems. The main reason of using Fuzzy logic is the only technique, which can handle imprecise, 'vague or fuzzy' information. The benefits of such fuzzification include greater generality, higher expressive power, an enhanced ability to model real world problems and a methodology for exploiting the tolerance for imprecision. Hence, Fuzzy logic can help to achieve tractability, robustness, and lower solution cost.

1.2 Project Problem Background

The large interconnected power system made the electricity distribution reliable and economical. This specific interconnection associated with multi locations open the complete system to become far more vulnerable to various steadiness complications. This problem is not only due to the complexity of the interconnection in a system but also due to the intermittent distributed generations and integration of other emerging technology in order to meet exponential growth of load demand beyond thermal and electrical limit of the system. The planning and operation using new ideas and new methods in solving challenging problems need to be done in fast and dependable mode. Substantial penetrations associated with DGs have an impact on the particular steady-state and also the design on the distribution system.

These impacts mostly consist of power quality disturbances for customers and electricity suppliers such as voltage regulation, voltage flicker, harmonic distortion and short circuit level. Most of the DGs (such as wind, fuel cells, PV arrays, microturbines) cannot produce reactive power. Thus, they cannot support voltage stability during dynamic state. Proper voltage controllers need to be designed to maintain the voltage stability of the distribution system. Therefore, it is necessary to consider voltage stability constraints for planning and operation of distribution systems.

1.3 Problem Statement

The large interconnected power system made the electricity distribution reliable and economical. However, this interconnection of multi areas exposed the entire system to be more vulnerable to various stability problems [2]. This problem is not only due to the complexity of the interconnection in a system but also due to the intermittent distributed generations and integration of other emerging technology in order to meet exponential growth of load demand beyond thermal and electrical limit of the system. The planning and operation using new ideas and new methods in solving challenging problems need to be done in fast and dependable mode. High penetrations of DGs affect the steady-state and the dynamics of the distribution system. These impacts mostly consist of power quality disturbances for customers and electricity suppliers such as voltage regulation, voltage flicker, harmonic distortion and short circuit level.

In this project, a method is presented to determine the optimal location of distributed generators using fuzzy expert system by considering power losses and voltage at each bus simultaneously and the size of distributed generators is determined by an analytical method. The effectiveness of the proposed method is tested with IEEE 14 test bus system.

1.4 Project Objectives

The following are the objectives of this project:

i. To model the distribution networks with DG system for voltage system stability studies

ii. To analyse the impacts of DG penetration on voltage stability

iii. To identify the optimal location and size of DG in a distribution system using Fuzzy Logic

1.5 Project Scopes

The following are the scopes of this project:

i. The methodology approach on this project will be based on the simulation output to determine the optimal location of distributed generators using fuzzy inference system by considering power losses and voltage at each bus simultaneously

ii. The size of distributed generators is determined by an analytical method.

iii. The load flow of the distributions system will be simulated and study in order to determine the capacity and locations of the DG.

iv. The standard IEEE 14 bus test system modeling networks have been simulated by using Power System Analysis Tools (PSAT) which is a MATLAB toolbox.

v. The obtained results are presented in graphical manner.

1.6 Organization of Report

This report consists of five chapters; Introduction, Literature Review, Methodology, Results and Analysis, and Conclusion and Recommendations for Future Work.

Chapter 1 explains the crucial aspect of the research work such as background of study, objectives of the project, and scope of the project.

Chapter 2 presents Literature Review on the distributed generations (DG), power loss index, and load flow methods.

Chapter 3 explains methodology in implementing and completing the project. IEEE 14-bus model, which has been used as a model to determine proposed method for loss reduction by injecting power locally at load centers is described. In this method, optimally located distributed generator is used to minimize losses and to improve the voltage profile of the distribution system. The optimal location of distributed generators using fuzzy logic and its size is calculated using an analytical method is explained.

In Chapter 4, results obtained from the simulation are presented and followed by discussion on the outcomes of the work. Finally, in Chapter 5 conclusion from the work is presented and recommendations for future works are elaborated.

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