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A DNR AND DGs SIZING CONCURRENTLY BY USING COMBINATION OF SOM AND EVOLUTIONARY PROGRAMMING

MUHAMMAD ZUHDI BIN DULKIFLI

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitle "*A DNR and DGs Sizing Concurrently by using combination of SOM and Evolutionary Programming*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :...

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To my beloved mother and father

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ABSTRACT

The improvement of the energy performance that means the reduction of energy loss is one of the important parts that must be developed. The installing of the Distributed Generation (DG) in distribution system can improve the voltage profile and the power loss reduction but the DG must be installed at suitable position or bus in the network system. The objectives of this study are to identify the suitable of DGs position, minimizing the power losses and determine the suitable size of DGs that can be installed to the system. In this work, 2 methods are combined; *Self-Organizing Maps (SOM)* for DGs positioning and implementation of *Evolutionary Programming (EP)* as an optimization method for determining of power loss and DGs sizing. The combination of these methods is applied to the IEEE 33-bus and 69-bus standard system. To determine the validity of the results, the combinations of SOM and EP for both systems are compared with the original configuration system, and reconfiguration using EP with random position of DGs in the systems respectively. The SOM and EP programming has been simulated in MATLAB environment. The combination of SOM-EP is suitable to apply in 33kV system which achieves the objectives of the study. However, the combination of SOM-EP is not suitable for 69 kV system because power losses reduction is not globally solve.

ABSTRAK

Penambahbaikan prestasi tenaga yang bermaksud pengurangan kehilangan tenaga ialah salah satu bahagian yang penting yang perlu dibangunkan. Pemasangan *Distributed Generation* (DG) dalam sistem pengagihan boleh meningkatkan Profil Voltan (VPI) dan Pengurangan Kehilangan Kuasa (PLR) tetapi DG perlu dipasang di tempat atau bas yang sesuai didalam sistem rangkaian. Objektif kajian ini ialah untuk mengenalpasti kedudukan yang sesuai bagi DG, meminimumkan kehilangan kuasa, dan menentukan saiz yang sesuai bagi DG yang akan dipasang kedalam sistem. Dalam kajian ini, 2 teknik telah digabungkan; *Self-Organizing Map (SOM)* bagi menentukan kedudukan DG, dan perlaksanaan *Evolutionary Programming (EP)* sebagai kaedah pengoptimum untuk pengenalpastian kehilangan kuasa dan saiz DG. Gabungan kaedah ini digunakan kepada standard IEEE 33 sistem bas dan 69 sistem bas. Untuk menentukan kesahihan keputusan, gabungan antara SOM dan EP bagi kedua-dua sistem dibandingkan dengan konfigurasi sistem asal dan konfigurasi menggunakan EP dengan kedudukan rawak bagi DG di dalam sistem masing-masing. Pengaturcaraan SOM dan EP telah disimulasi dalam persekitaran MATLAB. Gabungan SOM-EP sesuai digunakan dalam sistem 33kV yang telah mencapai objektif kajian. Walau bagaimanapun, gabungan SOM-EP tidak sesuai bagi sistem 69kV kerana tidak menyelesaikan pengurangan kehilangan kuasa.

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CHAPTER 1

INTRODUCTION

1.1. Motivation

Nowadays, the improvement of the electrical power system is one of the big aspects that must be considered. The technology, the power utility, and the green technology are the examples of issue that must be improved. The electrical power consists of many process. Start from the generation, transmission, distribution, until to the consumer. The power system will ensure that the light can continue light up. The power engineer must be ensure that the supplied power must be enough with the demand. Power quality is important thing that the engineer should be faced. The improvement of the energy performance that means the reduction of energy loss is one of the important parts that must be developed. The distribution of electrical power system is the last stage of power system before it will arrive to the consumer. To ensure the consumer can get enough power, the distribution network must have low power loss. To reconfigure the distribution network, the technique of reconfiguration also must be improved and use the proper method to get the best configuration of network.

1.2. Problem Statement

Increasing the area of industry, urban, and resident cause the increasing the demand of electricity. The increasing the demand of electricity became the challenging task to the power engineer which must ensure that the electrical power can be supplied consistently. Starting from the generation until to the distribution, the engineer should be alert to any problem that can cause the reduction of electrical power. The configuration of distribution network is one part that must be alert because lots of the power losses occur at distribution network. The switching status at the network can affect the losses value. The installing of the Distributed Generation (DG) also can improve the voltage profile and power loss reduction but the DG must be installed to the suitable position or bus at the network in order to improve the efficiency of distribution network. The requirement of network reconfiguration technique become the main issue to get the best switching status of network and ensure that the network in radial form. The network reconfiguration also must be considered to the time of switching configuration. The previous research state that the reconfiguration of switching status elements is complex combinatorial because the reconfiguration of network consist a lot of switching element. The technique of reconfiguration or usually knows the reconfiguration algorithm must be achieve the aim of the reconfiguration by including the suitable size of DG.

1.3. Objective

The main objectives of this research are:

i. To identify the suitable position of DG in the distribution network based on the bus characteristics.
ii. To minimize the power losses in the distribution network.
iii. To analyse the suitable size of DGs in the network system.

1.4. Scope

This research are to identify the suitable position of DGs inside the network system by using SOM technique and for minimizing power losses and determine the suitable size of DGs by using the implementation of Evolutionary Programming. The distribution network system is in radial form and the data system use the standard IEEE 33- and 69-bus systems.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

These parts are divided into four sections which are Distribution Network Reconfiguration (DNR), Distributed Generation (DG), Self-Organizing Maps (SOM), and Evolutionary Programming (EP). For the Distribution Network Reconfiguration, the research about the distribution system will be presented in this chapter to explain more about the distribution network system, the purpose of DNR, and the reconfiguration process. For the Distributed Generation (DG), there will be explain about the advantage to the network, the impact to the distribution network, and the characteristic of the bus that has been installed with DG. The SOM also will be used during this project. This part will explain about the SOM, the function of SOM, and the operation of SOM. And the last part is about the Evolutionary Programming. That will explain about the EP, the function of EP, the different of EP with another algorithm, and the benefit of EP to the system.

2.2 Distribution Network Reconfiguration (DNR)

The energy distribution utilities around the world are confronting the required of more efficient networks, because of the awareness from the public, so the management of the network becomes more common in the world.

The distribution is one of the important parts that will link the consumer with the transmission systems. The network reconfiguration is one of the tasks that must be face for the power engineer. The authors in [1] have explain that the distribution network reconfiguration is the changing the structure of distribution feeders by modifies changing the open/close status of the sectionalizing (normally closed) and tie (normally open) switches. This paper also state that the loss reduction in network reconfiguration is highly complex combinatorial, non-differentiable and constrained nonlinear mixed integer optimization problem, due to high number of switch elements in the network. The ROREDN tells about the optimization problems which is the modification of distribution feeders‟ structure by changing the status of open/closed switches [2]. The contributions of ROREDN are increasing the network efficiency and improve the system quality in term of power loss reduction, increasing reliability, energy restoration, voltage stability, and load balancing.

The paper [3] state that the network reconfiguration is the process of altering the topology of distribution feeders‟ structure by changing the open/closed status of its sectionalizing and tie switches with the aim to get the minimal losses topology. The authors in [4] state that the reconfiguration is not only to reduce the power losses, but also to relieve the overloading of the network components. This paper also state that the network reconfiguration is a complicated combinatorial, non-differentiable and optimization problems owing constrain to the enormous number or candidates switching combinations in the system. The objectives of the reconfiguration also stated at this paper which are the minimizations of system‟s power loss, the voltage and current constraints violation, and the switching number. In [5] state that the network reconfiguration is the varying process the topological arrangement of distribution feeders by changing the open/closed status of sectionalizing and tie switching. The reconfiguration is used for system loss reduction, load balancing, and enhances voltage fluctuation in distribution network.

The purpose of DNR is to find the operating structure in radial for minimizing the power loss. The [6] state that the distribution automation is the address for reconfiguration of radial distribution networks by the aim of achieving minimum losses operation. This paper state the reconfiguration solution strategy for minimum losses is divided into two different parts; dealing with the closing phase which is given in charge to neutral network, and controlling the opening phase which is based on deterministic algorithms, which locally checks the existence of a mesh in the current network configuration. In paper [7] state that the reconfiguration of network is to maintain the radial topology and to reduce the power losses at the feeders, to enhance the voltage profile for customers, and to increase the reliability levels. To solve the optimal of reconfiguration problems should consider the proper modeling of distribution networks elements and the electrical loads. The algorithms to handle the configuration changes in the network topology in a timely manner, the load-flow calculations, the composition of the objective functions and constraints. The optimization and the decision-making technique used to define the idea electrical configuration. In reconfiguration, the elements that‟s should be consider is the radial topology, the voltage limits, and the current profile constraint.

The most of distribution network operate radially, even though there are some interconnecting tie lines available to increase the system reliability. The tie lines will make the network to accommodate to the variation of load to achieve reduction of line losses [8]. The [9] state that the importance of smart reconfiguration for the operating conditions of such radial networks. The radial reconfiguration of the network is a viable option for ensuring optimal or nearly optimal operation in the presence of several constraints and the demand of variable power. The authors in [10] state that to minimize the energy losses is the radial reconfiguration of the electrical distribution systems based on the bio-inspired meta-heuristic Artificial Immune System. The process can be applied to determine the radial and connected network topology that minimizes the energy losses ad meets operational constraints. The apart of quality issues such as maintaining the node voltages within permissible limits and the feeder power losses minimization by appropriate selection of the network reconfiguration. The configuration in radial explored having better node voltage profile, the less of feeder power losses, and betters the reliability indices. The feeder power loss and the node voltage deviation are the important quality of power objectives that must be included in the distribution network reconfiguration [11].

For the [12] state that have 2 variations of network reconfiguration problems. First of the problem is the given of the input of distribution network with some initial state, by considering the loss at a single branch. If there are buses downstream of the faulty branch, the new switch state will be finding by lowest number of switch change operations and can bring back the power to those affected buses. The second of reconfiguration problem is like at the first problem, which finds the new switches state and the set of transformer tap-changer adjustments, so the power can bring back to the affected buses. The aim of both problems are same, which is the minimization of buses without power and with limits the voltage outside operational.

2.3 Distributed Generation (DG)

Nowadays, the Distributed Generation (DG) has been utilized to the electrical network. Paper [13] state that the some of the DG‟s advantages to the network are power loss reduction, environmental friendly, improvement of voltage, postponement of system upgrading, and the increasing the reliability. Some of the optimize tool have been modified to enhance their performance in solution or to overcome the limitation of the tool. This paper state that one advantage of deploying a DG-units is to minimize the total system of real power loss, while satisfying certain of operating constraints.

The DG should properly plan and operated to provide benefits to the distribution network. Otherwise, it can cause degradation of power quality, reliability, and the power system control. So, the main goals of proposed planning algorithm are to find the best locations for the new DG and the optimal size that will be installed to the network. The minimizing different function is related to the cost of energy losses. That is the statement from [14]. The authors in [15] state that the amount of distributed-generation resources (DGRs) and consider the reactive-power sources (RPSs) in the selected buses are determine by taking account of the outputs, with different load levels, tap positions of voltage regulators (VRs) and the status of sectionalizing switches, in order to achieve the aim to minimize the power cost, energy losses, and the total required reactive power. The condition of the operating system and the characteristic of DG will give the impacts to the system performance. To minimize the cost of power and energy losses and the total required reactive power, the amount of DGRs and RPSs in selected buses should be compute to make up the given total of distribution generation.

The [16] state that the DG can reduce the capital cost for the system by deferring the distribution facilities. The function of DG are to reduces the power flow of the system, improve the voltage profile, minimizing the system losses, relieving the heavy loaded feeders, and can extend the lifetime of the equipment. The [17] propose the switch placement schemes to improve the system reliability for radial distribution systems with Distributed Generation (DG) under the fault conditions. The system‟s operating condition, DGs characteristics and location will give the impact to distribution systems either positive or negative impact. This paper present that the positive impact includes the improvement of system reliability, loss reduction, deferment of new generation, and improvement of power quality. To get the benefits, DG must be reliable, dispatchable, of appropriate size, and at suitable location.

The [18] state that the increasing the penetration of DGs in distribution systems, the siting and sizing of DGs in the planning of distribution system becoming increasingly important. The inappropriate siting and sizing of DGs could lead to much negative effect such as the configuration of the relay system, the voltage profiles, and the losses in the network. The objectives of DG optimal location in radial are to minimize the network loss and to improve the voltage in distribution systems. To determine the optimal locations and sizes of DGs, three indices including the losses, voltage profile, and the short-circuit level are used.

The [19] state that the diffusion of DG into the network could be beneficial to improve the operation of network, but the excessive amount of DG in operation can cause the violations of the system constrains. This paper state that the weighted sum of individual objectives is formulated by considering the investment, the operation and reliability costs, the voltage profile improvement and loss reduction, DG cost and power losses, voltage profile and the voltage stability.

The [20] state that the main factors associated with the multiple DG sizing and placement procedure is scrutinized through a multi-objective optimization approach. The factors include the voltage stability, the power losses and the network voltage variations. To solve the multi-objective optimization problems, the Pareto Frontier Differential Evolution (PFDE) algorithm is presented. This paper state that the advantages of installing DGs of an existing system are postponing the upgrade of an existing systems, peak shaving, power loss reduction, low maintenance cost, high reliability, power quality improvement, the possibility to exploit CHP generation, meet the increasing demand without requirement of extravagant investment, and the shorter construction schedules.

The [21] state that the distributed generation is generally operated at a constant, pre-set, power factor and there is a need to preserve the power factor during optimization. The [22] state that the objective functions of the tailored OPF by giving the installed capacity of DG is to minimize the total reactive power (VARh) which provided by the grid to the distribution network. The distributed generation plants typically operate at constant power factor which present the most benefit to the active power production.

A propose of multi-objective methodology for optimal distributed generation allocation and the sizing for distribution systems. The objective function consider to the minimizing of cost for active and reactive losses, and to improve the voltage profile and reliability of the distribution systems. This statement was state in [23]. The [24] state that technical advantage cover wide varieties of benefits, such as line loss reduction, peak shaving, improvement of system voltage profile and hence increased the power quality an relieved transmission and distribution congestion as well as grid reinforcement. To obtain the best objective, the optimal DG size and bus location must be determined. The multi-objective optimization covers optimization of both cost and loss simultaneously.

2.4 Self-Organizing Maps (SOM)

SOM is one type of artificial neural network (ANNs) which the methodology was introduced by Kohonen in 1989. This mathematical model is designed based on the human"s brains. The [25] state that the purpose of SOM is to transform the incoming input patterns into a one or two dimensional discrete map. All nodes are forced to be self-organized through the feedback path and that"s why the system is called Self Organizing Maps (SOM).

The [26] state that the principal goal of SOM is to transform the patterns of arbitrary dimensionality into the responses of one- or two-dimensional arrays of neurons and to perform the transform adaptively in a topological ordered fashion.

2.5 Previous Techniques Review (Evolutionary Programming)

An evolutionary programming (EP) is a based technique to present the optimal placement of distributed generation (DG0 units which energized by the renewable resource such as wind and solar in a radial distributed generation. This statement was state by [27]

The evolutionary programming (EP) is an optimization algorithm based on the simulated evolution which is mutation, competition and the selection. Paper [28] state that the highly-nonlinear dynamic problem is an efficient evolutionary programming algorithm to solve the generation expansion planning (GEP) problem. Paper [29] state that the evolution is the process of biological optimization by including the mutation, competition and the selection. This paper states that the evolution is the result of the fundamental stochastic process which interacts in population from the generation to generation.

The improvement of evolutionary programming (EP) method is to solve the problems of reactive power optimization. The [30] state that the method with dynamic mutation and the metropolis selection is used to solve the multi-objective reactive power optimization with presented the deregulation environment. This multi-objective function includes the minimization the losses of the network, the voltage deviation, and the compensation cost.

The [31] state that the improvement of EP and its hybrid version combined with the non-linear interior point (IP) technique is to solve the optimal reactive power dispatch (ORPD) problems. This paper state the objective of ORPD is to achieve the adequate voltage profile with satisfies the operational constrains and minimizes the active losses.

As the branch of EA, to generate the new individuals, the EP uses only the mutation operator. The [32] state that the mutation has greater exploratory power than crossover and the EP is less likely to fall into the local minima. The [33] state that the EP only uses the mutation operator toreproduce offspring populations. It has been proving to get the better global search ability than other EA even though the converging is very slow.

The other function use of Evolutionary Algorithms (EP) is to determine the location of distributed generation (DG). The [34] state that the main aim the proposed algorithm is to determine the best location of generators with their optimal size by minimizes the different functions.

The Evolutionary Programming uses as the primarily on mutation operators to get the solutions of function optimization problems (FOPs). The EP is the important category of Evolutionary Algorithms (EAs). This statement was state at the [35] paper. The [36] present that the self-adaptive evolutionary programming (SAEP) is used to solve the non-linear and discrete optimization problem. This paper also states the SAEP was developed based on the stochastic mechanism and evolutionary process. The EP technique is a stochastic optimization method in the area of evolutionary computation. This statement was state by [37]. This technique uses the mechanics of evolution to produce the optimal solution to a given problems. This technique works by evolving the population of candidate solutions toward the global minimum through the use of a mutation operator and selection scheme.

The [38] state that the EA including the EP is the artificial intelligence which is the methods for optimization based on the natural selection mechanics, such as mutation, recombination, reproduction, selection, and etc. For the statement from [39], the genetic merit and the evolutionary algorithm is the possibility of applying them through a very large number of