AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Engineering

Optimal Management of Distribution Networks Regarding Reactive Power Generation

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

by

Ahmed Selim Abdelwahab Sayed

Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

Faculty of Engineering, Ain Shams University, 2015

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Statement

This thesis is submitted as a partial fulfilment of Master of Science 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

In traditional power system network, power flows through three stages: generation, transmission, and distribution. The power flows in one direction from generation until reaching final user in distribution network. In this configuration, the generation process has total authority of the electrical power system; this configuration is defined as a centralized electrical power system. Many problems appear in this configuration such as increasing loss in transmission power lines due to flow of power for large distance. Therefore, the smart grid was developed to improve the power system efficiency and reliability and overcome the issue of power losses in transmission lines. This is achieved through using advanced techniques in metering devices, bidirectional information, networking, and advanced control technology.

Distributed generators (DGs) are considered a main feature of a smart grid. DGs are defined as small units connected directly to a distribution network and can be based on Renewable Energy Sources (RES), such as wind and solar, or on traditional energy sources, such as diesel generators. On the other hand, many microgrids are developed through connecting many DGs together to supply a defined load in a rural region with the required power which is difficult to connect with the distribution network. These microgrids depend on RES; therefore, generation power from these sources is random as it depends on atmospheric condition, as well, the load is random depending on the load condition. Therefore an energy management system is necessary to be developed to balance between the active and reactive generation with the required active and reactive power under the operation conditions to achieve the optimal management.

Reactive power is very important in an electrical power system; it supports the transfer of the active power, supplies loads with the required

reactive power and security operation of electrical power system since it can affect the voltage level. As reactive power is produced from generation units, the cost is no longer free and must be estimated. Therefore, an operation cost function for each generation unit must depend on active and reactive power cost. This study introduces an optimization operation cost for distributed generators (DGs) in microgrid depending on active and reactive power cost instead of active power cost only. This study achieves reaching optimal management and verifying the required active and reactive power with minimum cost to save stability of the system. The main contribution in this thesis is illustrated with the new technique which is presented as the Teaching-Learning-Based Optimization (TLBO) technique. The TLBO is used for solving the economic dispatch problem to obtain optimal management with the minimum cost.

In this thesis, it is considered that considering DGs operate as PQ type which have a known power factor for each DG. The model used is a smart microgrid containing three DGs (Diesel, Solar, and Wind) and, a capacitor bank to supply the load with the required active and reactive power. The model is applied on IEEE 33 Standard Test System. This study is divided to two parts; the first part objective is to clarify the efficiency of two optimization techniques in optimizing operation cost for the system depending on active and reactive power cost instead of active power cost only. The second part objective is to select the optimal sizing and siting of the capacitor bank to achieve minimum operation cost and improve the voltage level at all buses.

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List of Abbreviations

RES	Renewable Energy Sources
DG	Distributed Generation
EMS	Energy Management Systems
PV	Photovoltaic
WT	Wind Turbine
EC	Economic Dispatch
DN	Distribution Network
PCC	Point of Common Coupling
ELD	Economic Load Dispatch
TLBO	Teaching-Learning-Based Optimization
HS	Harmony Search
HMS	Harmony Memory Size
HMCR	Harmony Memory Consideration Rate
PAR	Pitch Adjustment Rate
BW	Band Width
NI	Number of Iteration

Chapter 1. Introduction

1.1. General Overview

This chapter gives overview information about the thesis goals, motivation behind choice of thesis research point, and objectives needed to be achieved from this thesis. All chapters are also presented through a brief description of the major outlines in each chapter.

1.2. Motivation

With an increasing interest in renewable energy sources (RES) whether they are variable renewable energy resources such as wind and solar or thermal renewable energy resources, there is a challenge to connect and integrate these RES with the main power system network. Many countries achieved the integration of high units from renewable energy with the main grid successfully, but other countries are still facing this problem. The developed power system can integrate with the rise in RES. This development is achieved by increasing the power system flexibility; at the same time of developing power system, RES is developed also in operation by adding storage unit and control systems to can integrate with main network. This development helps to achieve the coupling between RES and main grid. Power systems have many types of renewable energy resources such as wind, solar, geothermal power, and hydropower.

Energy sources come from two main categories: the first is traditional energy sources (fuel and oil) and the second is RES. Traditional energy resources are the main power sources in the world, but, now with the advanced technology, RES increase gradually to solve the population problem and fuel cost of traditional resources.

1.3. Thesis Objective

By increased use of renewable DGs, in distribution network and in microgrids, the power is generated randomly because renewable DGs are dependent on the atmospheric condition and, at the same time, demand power is random also due to the changes in loads. Therefore, balance must be made between generation and demand, taking into consideration the operation cost at all times [1]. Management system (MS) is developed to achieve this balance and one of the main components of management system is economic dispatch which balances between demand and generation with minimum cost. Economic dispatch problem is solved by using many optimizing techniques used as software; optimization process repeats every slot of time to obtain optimal management.

Reactive power is very important in electrical power system; it supports transfer active power, supplies loads with required reactive power, and security operation of electrical power system since it can affect the voltage level. As reactive power is produced from generation units, the cost is no longer free and must be estimated. Therefore, operation cost function for each generation unit must depend on active and reactive power cost.

This thesis introduces optimization operation cost for distributed generators (DGs) in microgrid depending on active and reactive power cost instead of active power cost only. This study achieves reaching optimal management and verifying the required active and the reactive power with minimum cost to save stability of the system. The main contribution in this thesis is illustrated with the new techniques, which is presented as the Teaching-Learning-Based-Optimization (TLBO) technique and Harmony Search (HS) techniques.

The study is applied in microgrid model containing three DGs (diesel, solar, and wind) and capacitor bank and this model is applied in IEEE 33 Standard Test System. This study is divided to two parts; the first part objective is to clarify efficiency of two optimization techniques in optimizing operation cost for the system depending on active and reactive