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Deployment of Power Network Structural Topology to Optimally Position distributed Generator within Distribution System

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Abstract

Distribution system is very essential to load centre or service mains. This is because it is the final section of electric power system (EPS) to supply the consumers. Once this section is compromised, low voltage consumers will be denied of a reliable supply of electricity. One way to make supply to low voltage consumers reliable is by bringing generation close to them through distributed generators. However, location of distributed generator is very important with respect to the entire EPS security. In this study, power network structural topology (PNST) is proposed to optimally locate distributed generator within distribution system which results in minimal loss as well as maintaining voltage profile within constraint limits. 5-bus IEEE test system was used as case study to show the feasibility of the proposed method. Results obtained for both test systems were validated through the results from power world simulation tool.

Keywords: Optimal, Distributed generator, Distribution system, Power network structural topology.

1. Introduction

A direct result of meeting the need of electrical energy consumers is the concern of most of developing nations. Adequate and constant supply of electricity in some of the developing nations has been the major challenge towards their development in terms of industrialization, technological advancement, innovation, etc. [1, 2]. These problems persist mainly because daily load demand is greater than the available generated power [3]. Another problem is losses along the lines. If the difference between available generated power and load demand is very large, a new centralized generation station will therefore be of essence. However, if the difference is not very much, distributed generator (DG) can be a feasible alternative [4]. Distributed generator (DG) is referred to as a mini generation station that is installed very close to user end. It can either be stand alone or integrated into the power system network. It can be renewable energy source (i.e. biomas, hydro, wind, sun, geo-thermal and tidal) or non-renewable source (i.e. coal, gas, fuel cell). Integration of DG into distribution power system offers several benefits such as line loss reduction, improved voltage profile, increased power quality, relief in distribution capacity, etc.

One of the problems associated with the integration of distributed generator into the distribution network is optimization i.e. optimal sizing and siting of DG. This problem is usually solved as a non-linear problem using iterative approach. Several studies have considered different methods for placing and sizing DG [5]. Analytical method, based on exact loss formula, has be used by [6] on Nigerian 33-kV network to minimise real power losses which also resulted in voltage profile improvement. Loss sensitivity factor based on current injection method was proposed by [7], which was tested on 12-, 34- and 69-bus distribution systems. The proposed method was compared with Acharya's method and classical grid search algorithm. Other methods that have also been deployed are Newton Raphson method of load flow study [8], power flow algorithm [9], second-order power flow sensitivities [10], differential evolution [11], discrete particle swarm optimisation [12], ant colony optimisation [13], particle swarm optimisation [14]. Most of the previous methods deployed were based on iterative approach and varying location in order to ascertain optimal result.

In this present study, a new approach to finding optimal location and capacity of DG is proposed. This new approach is based on power network structural topology (PNST) devoid of any iterative process. Based on the results from PNST approach, power world simulation tool is used to ascertain the feasibility of this new approach to solving power system problem.

2. Methodology

In this section, power network structural topology (PNST) and power world simulation software are considered. The PNST is the proposed approach in this study while power world simulation software is used to validate the result obtained from PNST.

Power network structural Topology

Power network structural topology (PNST) is an approach that considers the inherent characteristic of electric power circuitry in order solve power system problems. PNST approach proposed in this study, is based on the two-port network technique which has been reported in previous works [15-17].

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