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Optimal Allocation of Combined DG and Capacitor Units for Voltage Stability Enhancement

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Abstract

Due to high penetration of distributed generation (DG) in distribution networks, transmission networks are no longer responsible solely for security issues in low-voltage distribution networks. DG units may also participate in security as well as power generation depending on their locations. In this paper, stability of Distribution system is studied based on voltage stability analysis as a security measure. Basic load flow is carried out on the well known 33- bus radial distribution network using forward backward sweep algorithm in MATLAB and voltage stability indices have been calculated. A priority list of DG and capacitor unit allocation for minimization of losses and improvement in voltage magnitude will be evaluated by evolutionary search algorithm i.e. Genetic Algorithm.

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Keywords: Distributed Generation(DG);Voltage Stability Index(SI);Radial Distribution Network; Genetic Algorithm.

1. Introduction

The three basic requirements of distribution system is proper voltage, availability of power on demand and reliability. Due to the load fluctuations in distribution system, the distribution system suffers low voltage and voltage variations. And in a radial distribution system the voltage level at the farther end is lower and low voltage levels hinders the performance of the equipments and loads connected to the system. So maintaining voltage levels within the acceptable limit is necessary. Also supplying power on demand becomes an important aspect with which comes the reliability of the system. As an effective solution to improve the performance of the distribution system

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interconnection of “Distributed generation (DG)” have emerged. Distribution generation reduces losses in the distribution system, supply power and improves the voltage profile of the system. DG’s are the small scale electric power generators that produce electricity at the distribution side of the power system [1]. Capacitors are used at the distribution side to locally provide reactive power and hence improve the voltage levels. Installing capacitor banks in distribution system can effectively reduce power loss and provide additional benefits for system operation [2].In order to voltage stability in the distribution system a stability index (SI) is used. The active power and the reactive power transferred are used for developing the stability index (SI). In this paper the optimal placement of DG and capacitors in the radial distribution network i.e. IEEE 33 test system is carried out as a multi objective optimization function. Genetic algorithm (GA) is used as the optimization tool. GA operates on a population of potential solutions applying the principle of survival of the fittest to produce (hopefully) better and better approximations to a solution. The impact of DG and capacitors on the network voltage profile and also reduction in the losses of the system is studied.

2. Distribution generation (DG)

Distributed generation (DG), unlike traditional generation, aims to generate part of required electrical energy on small scale closer to the places of consumption and interchanges the electrical power with the network. Distributed generation, also termed as embedded generation or dispersed generation or decentralized generation, is defined as small electric power source that can be connected to a distribution network.

2.1 *Types of Distributed Generation (DG).*

The DG’s are grouped into four major types based the real and reactive power delivering capability [3].

Type1: This type DG is capable of delivering only active power such as photovoltaic, micro turbines, fuel cells, which are integrated to the main grid with the help of converters/inverters.

Type2: DG capable of delivering only reactive power. Synchronous compensators such as gas turbines and capacitor banks are the example of this type and operate at zero power factors.

Type3: DG capable of delivering active power but consuming reactive power. Mainly induction generators, which are used in wind farms, come under this category. However, doubly fed induction generator (DFIG) systems may consume or produce reactive power i.e. operates similar to synchronous generator.

Type4: DG capable of delivering both active and reactive power. DG units based on synchronous machines (cogeneration, gas turbine, etc.) come under this type.

2.2 *Modeling of DG units.*

In order to model the DG in the optimization problem considering the type of DG, the injected active and reactive power at i^th bus are modeled as follows [4].

$$P_i = P_{DG_i} - P_{D_i} \quad (1)$$

$$Q_i = Q_{DG_i} - Q_{D_i} = \propto_i \times P_{DG_i} - Q_{D_i} \quad (2)$$

$$\alpha_i = (sign) \times \tan(cos^{-1}(PF_{DG_i})) \quad (3)$$

P_{DG_i} is active power generated from DG at i^{th} bus, Q_{DG_i} is reactive power generated from DG at i^{th} bus, P_{D_i} is active power demand at i^{th} bus, Q_{D_i} is reactive power demand at i^{th} bus and PF_{DG_i} is the DG power factor.

The power factor depends on the type of DG and the operating condition of the DG unit.

- Type 1 - PF_{DG_i}=1
- Type 2 - PF_{DG_i}= 0
- Type 3 – 0 < PF_{DG_i} < 1 and sign = -1
- Type 4 – 0 < PF_{DG_i} < 1 and sign = +1