DSTATCOM allocation in distribution networks considering load variations using bat algorithm

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Abstract This paper proposes a new method of scheduling for optimal placement and sizing of Distribution Static Compensator (DSTATCOM) in the radial distribution networks to minimize the power loss. In the proposed method Voltage Stability Index is used to search the optimal placement for installation of DSTATCOM. Optimal size of DSTATCOM is found by using bat algorithm. The feeder loads are varied by linearly from light load to peak load with a step size of 1%. In each load step, the optimal placement and sizing for DSTATCOM are calculated. By using the Curve Fitting Technique, the optimal sizing for DSTATCOM per load level is formulated in the form of generalized equation. The proposed approach will help the Distribution Network Operators to select the DSTATCOM size according to the load changes. To check the feasibility of the proposed method, system has been tested on two standard buses such as IEEE 33 and 69 bus radial distribution systems.

1. Introduction

In recent years, the distribution networks have attained much attention by the researchers because it plays a vital role in power system quality and planning. To introduce deregulation in power system, it causes the power quality problems such as voltage fluctuation, voltage sag and voltage instability in the distribution system. These power quality problems lead to power loss increase, slower response time and decrease in power flow limits [1,2]. From the literature it is observed that 13% of total generated power is wasted as a loss in the distribution side [3]. From the consumer point of view, the power loss reduction is one of the major important issues to improve the overall efficiency of the power delivery.

To resolve this issue completely, it requires to use highly advanced equipments for power loss reduction in the distribution network. Such equipments are capacitor banks, shunt and series reactors, automatic voltage regulator (AVR) or recently developed Distribution network Flexible AC Transmission (DFACTS) such as Distribution Static compensator (DSTATCOM), Unified Power Flow Conditioner (UPQC), and Static Synchronous Series Compensator (SSSC) [8]. Compared with other reactive power compensation devices, DSTATCOM has many features such as low power losses, less harmonic...
production, high regulatory capability, low cost and compact size [7]. In addition, the DSTATCOM does not have any operational problems such as resonance or transient harmonics unlike shunt or series capacitors [7].

DSTATCOM is a shunt connected Voltage Source Converter (VSC) which has been used in distribution networks to compensate the bus voltage so as to provide improved power factor and reactive power control. DSTATCOM has the capability of providing quick and continuous capacitive and inductive mode compensation. DSTATCOM can inject sufficient reactive current to compensate the bus voltage so as to provide improved power quality enhancement such as voltage regulation, voltage stability enhancement, reactive power compensation and power quality enhancement such as voltage regulation, voltage balancing a flicker suppression system [6].

Based on the literature review, determination of the optimal location and sizing of DSTATCOM has a considerable impact on radial distribution system. Only a few researchers worked under the area of DSTATCOM allocation. To find the optimal location of the DSTATCOM, various researchers have implemented various optimization algorithms such as differential evolution [7], immune algorithm [8], and particle swarm optimization algorithm [9]. In Ref. [7], a differential evolution algorithm is presented for optimal DSTATCOM allocation in radial distribution system with reconfiguration consideration. In [8], an immune algorithm approach for determining the optimal location and size of DSTATCOM with an objective function of power and energy losses reduction was investigated. Then in [9] particle swarm optimization algorithm is used for determining the optimal location and sizing of DSTATCOM and DG with an objective function of power loss minimization and voltage profile improvement. So many research work has been carried out on optimal allocation of DSTATCOM in transmission systems using different optimization techniques such as particle swarm optimization (PSO) and genetic algorithm (GA) [10–12].

Recently, a new meta-heuristic optimization technique, known as bat algorithm has been developed by Yang in the year of 2010 [13]. It is one of the latest nature inspired algorithms, used to solve complex and multiobjective optimization problems in various fields as well as power system applications. The authors in [14] presented the application of bat algorithm to find optimal placement and size of the Distributed Energy Resources (DERs) with load variation for minimizing the power loss and voltage profile improvement. Then in Ref. [15] bat search algorithm is used to achieve optimal power flow for generation reallocation with Unified Power Flow Controller (UPFC). The authors in Ref. [16], found optimal spot pricing in electricity market with inelastic load by implementing bat algorithm. The authors designed conventional power system stabilizer for small signal stability [17] and also optimal design of power system stabilizers in multimachine environment is achieved [18] by applying bat algorithm.

From the above literature it can be observed that authors obtained encouraging results in finding the DSTATCOM placement in radial distribution networks. However, these methods consist of several drawbacks with respect to computational time in solving DSTATCOM and all the authors have focused only on three load levels (light, medium and peak) and the load variation has not been considered in radial distribution system. For each and every change in load steps affects variation the optimal size of DSTATCOM, it will cause uncertainty in the distribution system for minimization of power loss. In addition to that authors implemented only single
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