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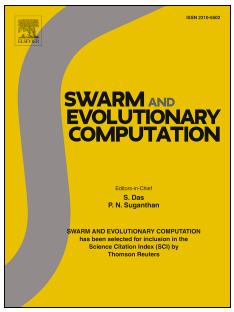

Optimal placement of TCSC and SVC for reactive power planning using Whale optimization algorithm

Saurav Raj, Biplab Bhattacharyya

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Optimal placement of TCSC and SVC for reactive power planning using Whale optimization algorithm

Saurav Raj, Biplab Bhattacharyya
Department of Electrical Engineering,
Indian Institute of Technology(Indian School of Mines), Dhanbad-826004, India.
Email: sauravsonusahu@gmail.com, biplabdgp1@rediffmail.com

Abstract: In the present work, Whale optimization algorithm (WOA), Differential evolution (DE), Grey wolf optimization (GWO), Quasi-opposition based Differential Evolution (QODE) and Quasi-opposition based Grey wolf optimization (QOGWO) algorithm has been applied for the solution of reactive power planning with FACTS devices i.e., Thyristor controlled series compensator (TCSC) and Static Var compensator (SVC). WOA is a recently developed nature-inspired meta-heuristic algorithm based on hunting behaviour of Humpback Whales; DE is a stochastic real-parameter optimization technique comprising of genetic parameters namely - mutation & cross-over; and GWO is a nature-inspired meta-heuristic algorithm based on hunting behaviour of Grey wolf. Standard IEEE 30 and IEEE 57 bus test system has been adopted for the testing purposes. Location of TCSC has been determined by the power flow analysis method and location of SVC has been determined by the voltage collapse proximity indication (VCPI) method. Further, WOA, GWO, DE, QODE and QOGWO algorithms have been applied to find the optimal setting of all control variables including TCSC, the series type and SVC, the shunt kind of FACTS device in the test system which minimizes active power loss and system operating cost while maintaining voltage profile within permissible limit. The superiority of the proposed WOA technique has been illustrated by comparing the results obtained with all other techniques discussed in the present problem. ANOVA test has also been conducted to show the statistical analysis between different techniques. The proposed approach shows lesser number of iterations which does not gets trapped in the local minima and offers promising convergence characteristics.

Key words: Grey wolf optimization; Reactive power; SVC; TCSC; Voltage collapse; Whale optimization.

1. Introduction

In the prevailing power system networks, the economic and environmental friendly transfer of electrical energy is a challenging task for the power system operators. Construction of new transmission lines to meet the current electricity demand cannot be considered a feasible option due to many reasons including the cost as one of the prime factor. The need for more efficient and fast responding electrical systems has prompted the use of a new technology based on solid-state devices in transmission system. The new technology includes Flexible AC transmission system (FACTS) devices with existing power system to improve the performance of the power system. In a connected power network, FACTS provides new opportunity for controlling the line power flow and minimizing losses while maintaining the bus voltages within a permissible limit. Effective and co-ordinated reactive power planning at weak buses of power system may help in minimizing active power loss and improve the voltage profile of entire connected power network.

Authors have presented simulated annealing based algorithm in [1-2] for the optimal placement of capacitors in a connected power network. Modal analysis method to determine the weak buses for the voltage stability improvement is described in [3]. The concept of