



Optimal location and controller design of STATCOM for power system stability improvement using PSO

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Abstract

The optimal location of a static synchronous compensator (STATCOM) and its coordinated design with power system stabilizers (PSSs) for power system stability improvement are presented in this paper. First, the location of STATCOM to improve transient stability is formulated as an optimization problem and particle swarm optimization (PSO) is employed to search for its optimal location. Then, coordinated design problem of STATCOM-based controller with multiple PSS is formulated as an optimization problem and optimal controller parameters are obtained using PSO. A two-area test system is used to show the effectiveness of the proposed approach for determining the optimal location and controller parameters for power system stability improvement. The nonlinear simulation results show that optimally located STATCOM improves the transient stability and coordinated design of STATCOM-based controller and PSSs improve greatly the system damping. Finally, the coordinated design problem is extended to a four-machine two-area system and the results show that the inter-area and local modes of oscillations are well damped with the proposed PSO-optimized controllers.

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1. Introduction

Reactive power compensation is an important issue in electrical power systems and shunt flexible AC transmission system (FACTS) devices play an important role in controlling the reactive power flow to the power network and, hence, the system voltage fluctuations and stability. Static synchronous compensator (STATCOM) is member of FACTS family that is connected in shunt with the system. Even though the primary purpose of STATCOM is to support bus voltage by injecting (or absorbing) reactive power, it is also capable of improving the power system stability [1]. It has been proved that shunt FACTS devices give maximum benefit from their stabilized voltage support when sited at the mid-point of the transmission line [2]. The first swing stability of the system is greatly influenced by choice of different models of the transmission line [3]. For long transmission lines, when the actual model of the line is considered, the results may deviate significantly from those found for the simplified model. With pre-defined direction of real power flow, the shunt FACTS devices need to be placed slightly off-center towards the sending end for maximum benefit from the transient stability point of view [4,5]. Application of GA to determine the optimal location of the shunt FACTS devices for transient stability improvement has also been reported in the literature [6].

Power system stabilizers (PSSs) are one of the most common controls used to damp out power system oscillations. When a STATCOM is present in a power system to support the bus voltage, a supplementary damping controller could be designed to modulate the STATCOM bus voltage in order to improve damping of system oscillations [7]. But, the interaction among PSSs and STATCOM-based controller may enhance or degrade the damping of certain modes of rotor's oscillating modes. To improve overall system performance, many researches were made on the coordination between PSSs and FACTS power oscillation damping controllers [8–11].

Although the local control signals are easy to get, they are not as highly controllable and observable as wide area signals for the inter-area oscillation modes. Due to restriction of local measurements, these controllers based on local signals tend to be difficult to offer satisfactory performance under various system operating conditions. With the rapid advancement in wide area measurement systems technology, fast communication networks and powerful information technology, the widely dispersed signals of power systems can be centralized, processed and distributed even in real time, which makes the wide area signal a good alternative for control input [12]. A number of conventional techniques have been reported in the literature pertaining to design problems of conventional PSSs: the eigenvalue assignment, mathematical programming, gradient procedure for optimization and also the modern control theory. Unfortunately, the conventional techniques are time consuming as they are iterative and require heavy computation burden and slow convergence. In addition, the search process is susceptible to be trapped in local minima and the solution obtained may not be optimal [13]. The evolutionary methods constitute an approach to search for the optimum solutions via some form of directed random search process. A relevant characteristic of the evolutionary methods is that they search for solutions without previous problem knowledge. Recently, particle swarm optimization (PSO) appeared as a promising evolutionary technique for handling the optimization problems. PSO is a population-based stochastic optimization technique, inspired by social behavior of bird flocking or fish schooling [14]. This paper proposes to use PSO technique to determine optimal location of STATCOM for transient stability improvement.

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