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Improvement of Stability in Solar Energy Based Power System using Hybrid PSO-GS Based Optimal SVC Damping Controller

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Abstract

This paper presents a dynamic stability study in a solar energy based power system connected to infinite bus based on optimal design of a Static Var Compensator (SVC). In the proposed study, SVC is incorporated in order to improve the rotor angle and voltage oscillations because of different disturbances created in the power system. A new computational hybrid optimization approach using Particle Swarm Optimization (PSO) and Gravitational Search (GS) technique is considered for designing an optimal SVC damping controller for an improved dynamic performance. The optimization technique is used for tuning the gains of proportional integral derivative (PID) controller. Transient oscillation results for conventional PID, PSO optimized PID and PSO-GS based PID are compared analytically as well as quantitatively. It is observed that the proposed PSO-GS based PID controller is robust and effective in minimizing the oscillations in the system as compared to the other two and thus improves the stability.

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Keywords: Dynamic stability;gravitational search;particle swarm optimization;solar photovoltaic.

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1. Introduction

The use of renewable energy resources has gained so much attention and popularity in the world as alternative energy to the conventional thermal, hydro and nuclear energy. But the increasing use of fossil fuels like coal, gases and petroleum product will create a deficiency in future along with some other issues like increasing price, environmental pollutions. Again increasing demand of electrical energy for a luxurious society forces the power engineers to think of alternative energy sources in the form of wind, solar, biomass etc. [1]-[2]. Among these resources, solar energy is the most promising and emerging as popular source of electrical energy in society having potential utilization for remote rural communities. However, there are many challenges which needs to be addressed for effective and potential use of solar photovoltaic (SPV) being a sustainable solution. There is a lot of opportunity for such technologies to provide a cost effective solution to demand of electricity for the rural poor peoples of developing nations. In addition, development and increasing number of micro grids and stand alone off grid and on grid operation requires improvements in system design and control.

In this context, dynamic stability issues taking place in rotor when the machine is subjected to small disturbances, [1-2] becomes a challenging task due to high penetration of SPV. Such disturbances may be created in the system due to variation in load, mal operation of protective equipments, or faults. They will lead to some stability problem which can be taken care by using Power System Stabilizers (PSS) or Flexible AC Transmission Systems (FACTS) controllers [3-6]. These techniques can be implemented using devices like Static Var Compensator (SVC), PSS etc. which are popularly used for reactive power compensation and hence for improvements in rotor angle and frequency stability. In addition to these, voltage stability can also be supplemented using optimal design of SVC controller. Some of the researchers use lag-lead compensator [7], PI [8] and PID controllers [9] etc. to increase the effectiveness of SVC as damping controller. But, the performance may be degraded due to heuristic selection of PID gains, which may deteriorate the system stability. Therefore, soft computing techniques are being popularly used to determine the optimal gains so that the performance can be further improved. In this context, intelligent techniques such as Evolutionary Programming (EP) [7], Genetic Algorithm (GA) [8], PSO [10], GS [11] and fuzzy inference system (FIS) [12] etc. are being widely used for the better design of PID controller. But, they are being heuristic population based search algorithms based on random parameter selection, may lead to pessimistic results.

Hence, this paper proposes a novel hybrid optimization technique based on PSO and GS, will alleviate the above mentioned limitations. It improves the search space because of hybrid action of PSO and GS to bring about the best possible results with respect to conventional controllers under different operating scenarios. Though, the computational burden will increase a little bit, the proposed approach will be robust and effective enough to minimize the peak overshoot and settling time of dynamic parameter oscillations. Again, a comparative analysis is carried out using the proposed and the conventional controllers to know the better performance under different operating conditions.

2. System Modeling

In this paper, a SMIB power system modeling as shown in Fig. 1 is considered for the stability study. SVC as a FACTS controller is incorporated for improving system stability under different operating scenarios. The mathematical modeling of the system is given as follows:

$$\frac{\Delta\omega}{\Delta t} = \frac{\Delta T_m - K_1\Delta\delta - K_d\Delta\omega - K_2\Delta E_q}{2H} \tag{1}$$

$$\frac{\Delta\delta}{\Delta t} = \omega_0\Delta\omega \tag{2}$$