Coordination of PSSs and SVC Damping Controller to Improve Probabilistic Small-Signal Stability of Power System With Wind Farm Integration

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***Abstract*—A modified fruit fly optimization algorithm (MFOA) combined with a probabilistic approach are proposed in this paper to coordinate and optimize the parameters of power system stabilizers (PSSs) and static VAR compensator (SVC) damping controller for improving the probabilistic small-signal stability of power systems with large-scale wind generation, taking into consideration the stochastic uncertainty of system operating conditions. It is generally accepted that there is a threat to the stability of power system with penetration of wind farm. In addition, the stochastic fluctuations of wind generation make PSSs tuning more difficult. In this paper, PSSs and SVC damping controller are employed for suppressing local and inter-area low frequency oscillation. In order to eliminate the adverse effect between PSSs and SVC damping controller, the MFOA based on the probabilistic eigenvalue is applied to coordinate and optimize their parameters. The effectiveness of the proposed approach is verified on two test systems.**

***Index Terms*—Modified fruit fly optimization algorithm (MFOA), power system stabilizer (PSS), probabilistic small-signal stability, static VAR compensator (SVC).**

I. Introduction

IN recent years, the installation of renewable wind energy has expanded rapidly. Many large-scale wind farms are integrated to power grids through 110-kV or 220-kV transmission lines, which bring great and direct influence on the stability of main power networks. Impacts of large-scale wind power penetration on the power system stability have received much attention [1]–[3]. The random fluctuations of wind power output increase the uncertainty of system power balance [4], which will result in adverse effects on the system dynamic stability, especially the small-signal stability. It is important to analyze the power system small-signal stability with probabilistic methods [1], [5] and consider the effects of uncertainty of wind farm output and stochastic changes of loads. References [1], [6], and [7] represent some investigations along that line. Their work verifies the effectiveness of the probabilistic approach and illustrates that the integration of large-scale wind farms could cause the power system probabilistic small-signal instability that could be difficult to overcome. However, [1], [6], and [7] do not propose effective measures to improve the probabilistic small-signal stability, especially for damping the inter-area mode with wind power variations.

Application of power system stabilizers (PSSs) is normally a first measure to enhance the system small-signal stability. Large-scale wind farm integration can induce a higher probability of system instability when compared to one without wind generation [6], [7]. Uncertain fluctuations of wind generator output also make PSSs tuning more difficult [8]. In some cases, when the use of PSSs cannot provide sufficient damping for inter-area power swing (0.1–0.7Hz), SVC damping controller is an alternative effective solution. The primary application of SVC in a power system with integration of wind farm is to maintain the busbar voltage and provide reactive power support [9], [10]. With a damping controller installed, SVC can provide extra damping [11], [12]. SVC and PSSs are all fast acting power controller devices. There is a potential possibility that these devices may interact adversely with each other and may not produce the expected performance. To improve their overall combined performance, it is necessary to coordinate and optimize the PSSs and SVC damping controller parameters. A few researches are made along that line [13]–[15]. However, [13] and [14] are based on linearized power system around certain specified operating points (i.e., deterministic). With a linearized model, controller settings which are able to stabilize the system around certain specified operating points may not perform satisfactorily at other points. In [15], the probabilistic eigenvalue sensitivity analyses are carried out for the design of PSSs and SVC damping controller for power system small-signal stability enhancement, without considering the stochastic fluctuations of wind power output.

In the design of controller parameters, one single parameter usually influences more than one oscillation mode. The genetic algorithms (GAs) [16], [17] and the particle swarm optimization (PSO) [18] have been widely used as optimization tools. However, the GA requires long computational time and also suffers

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