A Hankel matrix based reduced order model for stability analysis of hybrid power system using PSO-GSA optimized cascade PI-PD controller for automatic load frequency control

ABSTRACT

This paper presents the automatic load frequency control (ALFC) of two-area multisource hybrid power system (HPS). The interconnected HPS model consists of conventional and renewable energy sources operating in disparate combinations to balance the generation and load demand of the system. In the proffered work, the stability analysis of nonlinear dynamic HPS model was analyzed using the Hankel method of model order reduction. Also, an attempt was made to apply cascade proportional integral - proportional derivative (PI-PD) control for HPS. The gains of the controller were optimized by minimizing the integral absolute error (IAE) of area control error using particle swarm optimization-gravitational search algorithm (PSO-GSA) optimization technique. The performance of cascade control was compared with other classical controllers and the efficiency of this approach was studied for various cases of HPS model. The result shows that the cascade control produced better transient and steady state performances than those of the other classical controllers. The robustness analysis also reveals that the system overshoots/undershoots in frequency response pertaining to random change in wind power generation and load perturbations were significantly reduced by the proposed cascade control. In addition, the sensitivity analysis of the system was performed, with the variation in step load perturbation (SLP) of 1% to 5%, system loading and inertia of the system by ±25% of nominal values to prove the efficiency of the controller. Furthermore, to prove the efficiency of PSO-GSA tuned cascade control, the results were compared with other artificial intelligence (AI) methods presented in the literature. Further, the stability of the system was analyzed in frequency domain for different operating cases.

Keyword: Automatic load frequency control (ALFC); Hybrid power system (HPS); Cascade control scheme (CCs); Proportional integral – proportional derivative (PI-PD)control; Hankel method; Particle swarm optimization – gravitational search algorithm (PSO-GSA)