A Matignon's theorem based stability analysis of hybrid power system for automatic load frequency control using atom search optimized FOPID controller

ABSTRACT

The large-scale penetration of intermittent Renewable Energy (RE) sources such as wind and solar power generation may cause a problem of frequency aberration of interconnected Hybrid Power System (HPS). This occurs when the load frequency control of interconnected system is unable to compensate the power balance between generation and load demand. Also owing to the enhancement of future transport, the Plug-in Electric Vehicle (PEV) plays a significant role to customer at demand side. Thus, the PEV can act as a power control to compensate the power balance in Renewable Energy integrated power system. This paper presents a physics inspired Atom Search Optimization (ASO) algorithm for tuning the parameters of Fractional Order Proportional-Integral-Derivative (FOPID) controller for Automatic Load Frequency control of HPS. In this proposed work, an attempt has been made to analyze the frequency stability of HPS using Matignon's theorem. The interconnected HPS consists of reheat thermal power system, RE sources such as wind and solar thermal power generation associated with energy storage devices namely aqua electrolyzer, fuel cell and electric vehicle. The gain and fractional terms of the controller were obtained by minimizing the Integral Time Absolute Error of interconnected system. The robustness of ASO-tuned FOPID controller is tested on two-area HPS that was modelled using MATLAB/Simulink. The results obtained were then compared with other fractional order and classical integer order controllers. From the simulation results, it is inferred that the proposed ASO-tuned FOPID controller gives superior transient and steady-state response compared with other controllers. Moreover, the self-adaptiveness and robustness of the controller was validated to account for the change in RE power generations and system parameters. Furthermore, the effectiveness of the method is proved by comparing its performance with the recent literature works. The real-time applicability of proffered controller is validated in hardware-in-the-loop simulation using Real Time Digital Simulator.

Keyword: Automatic load frequency control (ALFC); Atom search optimization (ASO); Fractional order proportional-integral-derivative (FOPID); Hybrid power system (HPS); Plug-in electric vehicle (PEV)