Application of Soft Computing Techniques in Power System Security Analysis

Thesis submitted by

Saborni Das

Reg. No.: 101711503007

(Index No.: D-7/E/446/16)

Doctor of Philosophy (Engineering)

Department of Power Engineering

Faculty Council of Engineering and Technology

Jadavpur University

Kolkata, India

June 2021

Abstract

For the last two decades, global as well as regional energy scenarios have been experiencing various challenges due to rapid exhaustion of conventional fossil fuels and subsequent high-level penetration of integrated renewable energy resources into the modern power system.

Prompt population expansion, social-economic development, and technical advancement, ecological pandemonium make mankind to rethink on the strategic utilization of residual fossil fuels and integration of renewable energy resources which are of stochastic and intermittent in nature. All these issues significantly dispute the secure planning, operation and management of the power system. Thus, analysis of the overall technical, ecological and economic security of power systems with renewable energy resources has become challenging and widely trending in present years.

Power system security analysis deals with sudden interruptions or contingencies in the system. A power system, in normal operating condition, may face contingency conditions, such as component outages or faults in generating units and other power system components, uncertainties or sudden changes in renewable energies and load demand from the forecasted values and so on.

Initially deterministic approaches were being exercised for power system security analysis. But the stochastic system behaviors are unaccounted for in such methodologies and their practice does not reflect actual scenarios of the underlying phenomenon. Consequently, different soft computing techniques were gradually being adopted for power system security studies. This dissertation is oriented towards some research advancements in this area.

The power system security tradeoffs that are presented here incorporate component outages and uncertainty issues of power system and their solution using soft computing techniques.

Module level outage is considered in case of open circuit and short circuit fault diagnosis of photovoltaic system using soft computing techniques. Identification of outages of photovoltaic modules, determination of type of module faults and tracing the location of the faulty modules in a photovoltaic array are effectively performed using improved real-coded genetic algorithm.

Another study incorporates outage scenarios of renewable components in case of day-ahead bidding in microgrid. The study also focuses on uncertainties related to load demand, renewable energy generations and outage schedules and their distributions during day-ahead bidding planning. To deal with outages of renewable generations different probability distribution functions are adopted. Demand response program is formulated considering outage-based contingencies. Chaos theory is introduced to generate stochastic scenarios of uncertain variables. The reserve and penalty costs for erroneous estimation of renewable energies are cited to design more secure economic bidding. To deal with uncertainties two-stage stochastic programming is adopted. This stochastic bidding problem is structured as a mixed integer nonlinear optimization problem and is solved using soft computing based LINDOGlobal solver.