



Research paper

Optimal power flow and grid frequency control of conventional and renewable energy source using evolutionary algorithm based FOPID controller

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ABSTRACT

The primary objective of optimal power flow (OPF) in power systems is to minimize fuel expenses while simultaneously addressing several critical factors, including reducing transmission losses, minimizing voltage variations, and enhancing overall system stability. As the energy landscape evolves, the integration of renewable energy sources (RES) into the power grid has become increasingly important. In this research article, a study of Automatic Generation Control including RES to achieve cost optimization highlighting the advantages of GZA algorithm through a comprehensive study with other two evolutionary algorithm has been done. The research focuses on a three-area system integrating renewable energy sources – specifically solar, wind, and electric vehicles (EVs) – within a deregulated environment. While these sources can significantly reduce fuel costs associated with thermal power plants, they also introduce new challenges. Specifically, the variability and unpredictability of renewable energy can lead to increased frequency deviations due to changes in load inertia. This frequency deviation can disrupt the synchronization of the power system, potentially compromising stability and reliability. Detail study has been done in the simulation results for frequency deviation to achieve LFC, emphasizing performance metrics like overshoot, undershoot, and steady-state stability. Both traditional PID and FOPID controllers were evaluated for their effectiveness in managing frequency deviations. LFC ensures that the frequency of the power system remains within acceptable limits, particularly in a multi-area system where different regions may experience varying loads and generation capabilities. Effective frequency control is essential for maintaining the balance between generation and consumption, which is vital for the smooth operation of the grid. This innovative approach aims to enhance frequency regulation by effectively managing the dynamics introduced by the incorporation of renewable energy sources alongside traditional thermal power generation. The findings aim to demonstrate the effectiveness of the evolutionary algorithm GZA in enhancing the overall performance of multi-area power systems with diverse generation sources. By providing insights into the benefits of advanced control strategies, this study has introduced a novel approach to simultaneously minimize costs and manage frequency deviations, marking a significant advancement in the field.

1. Introduction

In recent years, renewable energy sources have increasingly replaced conventional energy sources in power grids. As a result, the structure of power grids is evolving with the growing integration of renewable energy. In [1] optimizing fuel usage is essential to minimize costs, a key factor in achieving Optimal Power Flow (OPF) is highlighted. In [2] sole reliance on conventional energy sources has led to higher fuel costs, increased emissions, greater active power losses and voltage instability have been discussed. In an effort to encourage the

use of renewable energy sources, the authors of [3] have developed a control algorithm that would allow Thermostatically Controlled Loads to participate simultaneously in Power system Load frequency management and active distribution Configuration. By incorporating renewable energy, these fuel costs can be significantly reduced, thus helping achieve the primary objective of OPF. In a reorganized arrangement, the Load Frequency Control (LFC) of a linked two-area multiple-unit thermal reheat power system was examined [4].

Inadequate balance of frequency due to use of renewable sources has been discussed in [5]. OPF issues with fuel prices, emissions, and

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