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ADVANCEMENTS IN DC MICROGRIDS: CONTROL STRATEGIES AND THE ROLE OF ARTIFICIAL INTELLIGENCE

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Abstract

This research explores the resurgence of DC applications in power systems, focusing on the integration of DC microgrids and the effectiveness of control strategies in managing such systems. The research aims to investigate how artificial intelligence (AI) can enhance the efficiency of DC microgrids, especially in the context of renewable energy sources (RES) integration. The methodology involves a comprehensive review of existing literature on the evolution of DC and AC power systems, with a particular emphasis on voltage regulation. The research examines various DC microgrid control methods, including centralized, decentralized, distributed, and hierarchical strategies. Special attention is given to the role of AI, machine learning, and the Internet of Things (IoT) in the tertiary level of hierarchical control, which aims to optimize system performance. The findings highlight the advantages of DC microgrids, particularly their

compatibility with RES like Solar Photovoltaics (PV) and energy storage systems, as well as modern electrical appliances. Hierarchical control, with its primary, secondary, and tertiary levels, effectively manages voltage, power sharing, and operational efficiency. The tertiary level of control, when combined with AI technologies, significantly enhances the microgrid's performance through real-time data analysis and predictive decision-making, improving responsiveness and the integration of renewable energy. The research concludes that hierarchical control methods, augmented by AI, enable reliable, stable, and efficient operation of DC microgrids. These strategies improve the coordination of distributed generation, reduce operational costs, and enable participation in energy markets, promoting the sustainability of power systems. Future research should focus on advanced AI algorithms for optimization, exploring scalable control methods for larger microgrids and hybrid AC-DC systems to enhance energy transfer and storage capabilities.

Keywords:

DC Microgrid, Renewable Energy Sources (RES), Control Strategies, Hierarchical Control, Artificial Intelligence (AI)