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Research on A Comparative Analysis between UPFC and DPFC in a Grid Connected Wind Turbine System

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Abstract: *In the evolving landscape of renewable integration, voltage instability and reactive power mismatch pose significant challenges, particularly in wind-integrated power systems. To address these issues, Flexible AC Transmission Systems (FACTS) devices offer a robust solution. This paper presents a comparative analysis between two advanced FACTS controllers: the Unified Power Flow Controller (UPFC) and the Distributed Power Flow Controller (DPFC), integrated within a grid-connected wind turbine setup. The simulation is carried out using MATLAB/Simulink, focusing on voltage stabilization, power quality enhancement, and harmonic mitigation. The UPFC model, utilizing 48-pulse converters and centralized control, demonstrates its traditional strength in dynamic voltage control and reactive power compensation. Conversely, the DPFC architecture decentralizes the functionality of UPFC by replacing the common DC link with distributed single-phase D-STATCOMs and a central series converter, enhancing modularity and reducing installation costs and electromagnetic interference.*
Performance metrics such as voltage profile regulation, total harmonic distortion (THD), active and reactive power flow control, and system stability under transient conditions are thoroughly analysed. Results highlight that DPFC outperforms UPFC in terms of modularity, cost-efficiency, and fault tolerance, while UPFC still shows superior centralized control for sharp reactive compensation. This comparative study provides insights into the appropriate selection of FACTS devices for enhancing grid reliability in wind-dominated energy systems.

Keywords: Wind Energy, UPFC, DPFC, FACTS Devices, Power Quality, Voltage Stability, Simulink, Harmonics, Smart Grid.

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