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Bidirectional Converters and Reactive Power Control in DFIG Wind Farms: A Pathway to Carbon-Neutral Grid Reliability

Keshav Pratap Yadav, Lalit singh
Assistant Professor
R.R. Institute of Modern Technology, Lucknow, India

Abstract: *The global shift toward renewable energy has positioned wind power as a critical component of sustainable electricity generation. This study investigates the integration of Doubly-Fed Induction Generators (DFIGs) in wind farms, focusing on their dynamic performance, fault resilience, and grid compatibility [7]. A MATLAB/Simulink-based 9 MW wind farm model was developed[6], comprising six 1.5 MW DFIG turbines connected to a 120 kV grid via step-down transformers and π-section transmission lines. Simulations under variable wind speeds and fault conditions (single-phase and ground faults) demonstrated the DFIG's ability to regulate reactive power[10], optimize energy capture through variable-speed operation[9], and maintain transient stability. The bidirectional converter's role in decoupling active/reactive power control was validated [13], eliminating the need for external capacitor banks. Results highlight the DFIG's superiority over conventional fixed-speed systems in enhancing grid reliability[12] and reducing carbon footprints. This work underscores the feasibility of DFIG-based wind farms for large-scale renewable energy integration.*

Keywords: Doubly-Fed Induction Generator (DFIG), Wind Energy Conversion System (WECS)

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