Notification No: 589

Notification Date: 25/11/25

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THESIS TITLE: **DESIGN AND IMPLEMENTATION OF INTELLIGENT CONTROLLERS FOR WIND POWER SYSTEM**

RESEARCH HIGHLIGHTS:

The global transition to sustainable energy has positioned wind power as a critical contributor, with Doubly Fed Induction Generator (DFIG)–based turbines widely preferred for their high efficiency, variable-speed operation, and independent active–reactive power control. Despite these advantages, DFIG systems remain highly vulnerable to grid disturbances such as voltage dips, frequency deviations, harmonic pollution, and sudden wind gusts, all of which degrade dynamic stability and compromise power quality. This thesis develops a rigorous d–q reference-frame model of the complete DFIG system, incorporating the Rotor Side Converter, Grid Side Converter, DC-link dynamics, crowbar-based LVRT protection, and a rotor-speed-dependent MPPT scheme. Initial control using Ziegler–Nichols–tuned PI controllers show acceptable steady-state performance but suffers from sluggish response, parameter sensitivity, and limited disturbance rejection under real-world operating conditions.

To overcome these deficiencies, an ANFIS–PI hybrid controller is designed, leveraging neural adaptivity and fuzzy rule-based reasoning to achieve improved damping, reduced overshoot, and faster convergence. Although its performance is superior, the computational demand, rule complexity, and training overhead present significant challenges for real-time embedded implementation. To address this gap, the thesis proposes a Support Vector Regression (SVR)-based controller as a lightweight yet highly effective machine-learning solution. Trained offline using high-quality datasets extracted from PI-controlled system responses, the SVR controller exhibits excellent generalization, nonlinear mapping capability, and low computational cost. Simulation results show that the SVR controller significantly enhances transient performance—reducing torque oscillations by 28%, DC-link ripple by 40%, and rotor-speed overshoot by 17% compared to PI, while also outperforming ANFIS-PI in terms of adaptability and settling time. Furthermore, the SVR controller demonstrates strong robustness against stochastic wind variations, making it ideal for practical deployment in embedded DSP- and FPGA-based wind energy conversion systems. Overall, the work establishes SVR as a promising next-generation control strategy with an optimal balance of accuracy, computational efficiency, and real-time feasibility for modern DFIG-based wind turbines.