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Faculty of Engineering

Electrical Power Department

Advanced Control Techniques Applied to Renewable Energy Systems

By

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ABSTRACT

The master thesis has undertaken a comprehensive exploration of advanced control techniques for wind turbine systems, introducing two novel controllers, the Simplified Universal Intelligent PID (SUI PID) and the Simplified Optimum PID (SO PID). Both controllers exhibit distinctive attributes that enhance control methodologies.

Through thorough comparative analyses against a conventionally optimized PID controller using Particle Swarm Optimization (PSO), the study demonstrated the superior performance of the SO PID controller, particularly in the wind turbine pitch system, showcasing remarkable responsiveness across various operating setpoints. Furthermore, the SUI PID controller, applied not only to the wind turbine Permanent Magnet Synchronous Generator (PMSG) system but also to the pitch system and the regulation of the DC link voltage in the Grid Side Converter (GSC), displayed superior responses compared to the PSO-tuned PID controller. Its automatic gain adjustment based on normalized error values and the plant independent nature underlined its effectiveness in adapting to varying system dynamics. Expanding the scope to include aspects such as Maximum Power Point Tracking (MPPT), Machine Side Converter (MSC), and Grid Side Converter (GSC) within the PMSG system further emphasized the efficacy of the SO PID controller. Its model-based nature facilitated superior responses in regulating inner current loops for both MSC and GSC, the results compared to the PSO to ensure their effectiveness and adaptability.

In essence, this thesis not only introduces innovative control methodologies but provides empirical evidence of their effectiveness. The proposed controllers, particularly the SO PID and SUI PID, demonstrate remarkable adaptability to varying system dynamics, showcasing their potential for real-world applications. This research contributes valuable insights, affirming the SUI PID's better response in the pitch system and its role in regulating the DC link voltage in the GSC, further solidifying the potential impact of these controllers on optimizing wind turbine system performance.