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A Power Smoothing of Wind Generators Based on a Flywheel Energy Storage System

By

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A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Electrical Engineering

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STATEMENT

This Thesis is submitted to Ain Shams University in partial fulfillment of the requirements for M.Sc. degree in Electrical Engineering.

The included work in this thesis has been carried out by the author at the department of electrical power and machines, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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Abstract

Wind energy is one of the most important renewable energy sources as it has high potential in many sites compared to other renewable sources. Its importance has been increased as many countries need to reduce their fossil fuel consumption and to reduce the greenhouse gas emissions. One of the main problems in wind energy is the fluctuations in the wind speed which in return affect the output wind power. Fluctuations in the output wind power have bad effects on the power quality especially in small grids such as Microgrids. Therefore, smoothing wind power is a vital process to allow increasing wind integration into the grid. One of the most favorable methods to smooth wind power is using energy storage devices like batteries, super capacitors, and flywheels.

This thesis proposes a control strategy to control the Flywheel Energy Storage System (FESS) driven by Reluctance Synchronous Machine (RSM) to smooth wind output power. First, the smoothed output power is determined by using second order adaptive notch filter (SOANF). Then, the back to back converter is controlled to supply the smoothed power to the grid. The Function of the RSM side converter is to control the charging/discharging process of the flywheel in order to absorb wind power fluctuations. This is done by using vector control strategy where the RSM rotor position is determined by using sensorless control based on ADALINE observer, while the grid side converter is controlled to keep the dc link voltage at constant value. Finally, the FESS driven by Permanent Magnet Synchronous Machine (PMSM) is examined. Then, another control strategy for the back to back converter is proposed, where the PMSM side converter is made responsible for controlling DC link voltage, while the grid side converter is responsible for controlling output grid power.

The dynamic performance of the proposed control strategies are studied using PSCAD/EMTDC software. The simulation results show acceptable behavior of the proposed filtering technique and the strength of the proposed control strategy for both converter sides. The results also validate the RSM rotor position estimation technique.

Keywords--Adaptive notch filter, back to back converter, Flywheel, RSM, ADALINE, Rotor Position Estimation, PMSM.

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