Wind Energy

Session 19-1

DATE: WEDNESDAY, MARCH 25, 2009

Breakout Session 19-1:

Time: 1:30pm - 3:15pm

Session Chair: David Yu, University of Wisconsin Milwaukee

Presenters:

Wind Turbine Blade Design
Ryo Amano, UW-Milwaukee
Wind energy has been shown to be one of the most promising sources of renewable energy. With current technology, the low cost of wind energy is competitive with more conventional sources of energy such as coal. This however is only true in areas of high wind density. These areas are not as abundant and therefore the number of profitable sites is limited. This talk explores the possibility increasing the number of profitable sites by optimizing wind turbine blade design for low wind speed areas. The two methods of optimization that are investigated are first, optimizing the angle of attack and chord length for a given airfoil cross section at different positions along the blade and second implementing a swept blade profile. The torque generated from a blade using only the first optimization technique is compared to that generated from a blade using both techniques as well as that generated by NTK500/41 turbine using LM19.1 blades. Performance was investigated using the CFD approach for both straight and swept edge wind turbine blades.

Maximizing Wind Turbine Energy Capture Using Multivariable Extremum Seeking Control
Yaoyu Li, UW-Milwaukee
Co-presenter: John Seem

Maximizing wind turbine energy capture has become an important issue as more turbines are installed in low wind areas. Model based wind turbine control methods, which rely on predicted power maps for setting the reference pitch angle and rotor speed, have limitation in energy capture for field operation, due to complexity of turbine aerodynamics, inaccuracy in wind measurement and variation of turbine characteristics. This research investigates the development of a self-optimizing control strategy, the Extremum Seeking Control (ESC), to maximize the energy capture of variable speed wind turbine. The optimal control torque and pitch angle are searched via ESC based on the measurement of the rotor power. The advantage of this method is the independency from accurate turbine model and wind measurement. Simulation was conducted on the dynamic model of NREL's CART facility, under smooth, turbulent and field recorded wind profiles. The simulation results demonstrated significant improvement in energy capture compared to the standard control with fixed reference. An anti-windup ESC was applied to overcome the integral windup due to actuator saturation which would otherwise disable the ESC process. Finally, the integrator and high-pass filter resetting schemes were applied to improve the transient under the abrupt changes of wind.

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Grid Integration Issues for New Wind Turbine Generators

Adel Nasiri, UW-Milwaukee

It is recognized that renewable energy will be part of the sustainable future energy mix. Wind energy is also considered to play a major role in renewable energy portfolio. The achieve higher penetration of wind energy, many technical and non-technical issues need to be addressed. The main objective of this presentation is to discuss and address two problems of new wind generators namely: power variations and low voltage ride through. First, a new wind turbine system model recently developed by UWM power electronics and motor drives laboratory will be presented. This model features modeling of the system from wind to grid including turbine, generator, controls, and grid interface.

A new technique will be discussed to overcome the low voltage ride through issue for doubly fed induction generators. The proposed system introduces voltage on the stator of the generator to limit the short circuit current in the rotor side converter.

Utilization of rotor inertia, ultracapacitor, and battery energy storage will also be discussed to manage the power, voltage, and frequency variations at the wind farm output. Rotor inertia and ultracapacitors can be utilized for short term power smoothing and batteries can be used for longer terms power smoothing and energy management.

Probabilistic Load Flow for a Wind Power System based on a 5 Point Estimation Method

David Yu, University of Wisconsin Milwaukee

Load flow analysis is an important tool for planning future power systems. A constant power supply produces a constant load flow and hence load flow analysis needs to be performed only once. However, with a variable power supply, load flow analysis needs to be performed each time the power supply changes. In the case of power generated by wind turbines, the power supply is not only variable, it varies randomly. As a result the load flow solution parameters also become random variables. Therefore, for capturing realistic system performance, it is necessary to know the probabilistic behavior of load flow for a given probabilistic behavior of power supply. As a result of this random behavior by wind turbines, probabilistic load flow calculations must be done. This paper develops a five point estimation method providing an efficient method to make probabilistic load flow calculations on systems with power variation from wind turbines. The unique features of this method include are discussed. Simulations are run under a number of scenarios: varying wind penetration, varying the number of wind farms, and by changing the amount of variation at each wind farm. Finally the point method simulations are validated.

See presenter biographies next page

Presenter Biography:

Ryo Amano
Ryo Amano has been working on turbomachinery research for over 20 years. He has published a book entitled "Thermal Engineering in Power Systems—WIT Press" 16 book chapters and over 450 refereed journal papers and proceedings. He received three best paper awards all from ASME Power Division and ASME Computer & Information Engineering Division. He is a recipient of AIAA Sustained Service Award and ten ASME organizing awards. He has served as international advisory board member in many conferences in energy systems, heat transfer and fluid mechanics. He is currently ASME Fellow and AIAA Associate Fellow.

Dr. Yaoyu Li
Dr. Yaoyu Li is an Assistant Professor in the Department of Mechanical Engineering at the University of Wisconsin – Milwaukee. His research interest is in mechatronics and control systems, with a strong emphasis on energy efficiency, alternative and renewable energy systems. His current research is mainly focused on modeling and control of building HVAC systems, power management of plug-in hybrid electric vehicles and wind turbine control systems. Dr. Li obtained his B. Sc. from Tsinghua University (China) in 1992, M. Sc. From University of Saskatchewan (Canada) in 1997 and Ph. D. in Mechanical Engineering from Purdue University in 2004.

Dr. John E. Seem
Dr. John E. Seem, who is a Research Fellow in the Johnson Controls, Inc. Research Department, earned his Ph.D. in Mechanical Engineering from the University of Wisconsin-Madison in 1987. He also has a M.S. Degree in Mechanical Engineering and B.S. degrees in Agricultural Engineering and Mechanical Engineering from the University of Wisconsin-Madison. Dr. Seem has been leading adaptive control research and testing for the Building Efficiency Group of Johnson Controls, Inc. He also researches automatic tuning, fault detection and control of heating, ventilating, and air-conditioning (HVAC) equipment in commercial buildings. He is inventor or co-inventor on 24 United States patents.

Adel Nasiri
Adel Nasiri received the B.S. and M.S. degrees from Sharif University of Technology, Tehran, Iran, in 1996 and 1998, respectively, and the PhD degree from Illinois Institute of Technology, Chicago, Illinois, in 2004, all in electrical engineering. He worked for Moshanir Power Engineering Company, Tehran, Iran and ForHealth Technologies, Inc., Daytona Beach, Florida. Dr. Nasiri is presently an Assistant Professor in the Department of Electrical Engineering and Computer Science at the University of Wisconsin–Milwaukee. His research interests are renewable energy systems, power electronics converters, and electric motor drives. He has numerous journal and conference papers and presentations.