Editorial: Special Issue on Wind Applications Part 1

DRIVEN by the environmental concerns resulting from traditional energy sources, the rapid wind power installation in recent years has attracted much attention from academia, industries, and policymakers. Based on American Wind Energy Association (AWEA), total installed wind capacity in the U.S. at the end of 2012 has reached 60 007 megawatts (MW) with more than 13 000 MW of new installation in year 2012 alone. Worldwide, based on statistics from World Wind Energy Association, 14 000 MW of new wind power was installed in the first half of 2013 and global wind installations have almost reached 300 000 MW. Among the many functional components in wind turbine generators, power electronics converters and the associated controllers are key enabling technology. They play crucial roles in maximizing wind energy conversion efficiency in modern wind turbine generators. The challenge in the coming years lies in developing new techniques at the lowest possible cost and at the highest possible efficiency for wind power applications, to which the special issue is dedicated. The topics of interest for this Special Issue include: wind energy harvesting, modeling and simulation of wind power converters, power electronic converter topologies for wind turbine generator systems, control of power electronic converters for wind turbine generators, condition monitoring, fault diagnosis, and protection for power electronic converters and machines in wind turbine generator systems, power electronics and control for small wind turbine systems in residential applications, synchrophasor applications in wind power generation, wind power grid connection issues, offshore wind power generation, FACTS applications for wind power, power electronics and control for energy storage in wind applications. This Special Issue is organized into two parts. Part 1 appears in this December 2013 issue with 11 original papers. Part 2 will appear in early 2014.

This special issue starts with a review paper by Y. Zhao, C. Wei, Z. Zhang, and W. Qiao, on sensorless control for permanent magnet synchronous generator (PMSG) based wind energy conversion systems (WECS). The paper provides a comprehensive summary of the state of the art of sensorless control of PMSG based WECS including wind speed sensorless maximum power point tracking (MPPT) control schemes, vector control schemes without machine rotor position and speed sensors, direct torque control and direct power control. The sensorless control technologies can greatly help reduce the costs and maintenance of wind turbines.

The second paper is by L. He, Y. Li, and R. G. Harley, which develops an adaptive sliding mode control algorithm for PMSG-based WECS in a micro grid. The proposed control system considers two operating modes of the wind turbine: MPPT mode and non-MPPT mode. The automatic switching between the two modes is achieved with the new control strategy, which has enhanced control performance including robustness, accuracy and faster response. Controller performance is demonstrated by simulation and experimental results.

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The third paper by A. Balogun, O. Ojo, and F. Okafor applies nonlinear control techniques based on feedback linearization to doubly-fed induction generator (DFIG)-based WECS. Decoupled torque controller and decoupled power controller are developed with robustness against machine parameter variations. Both simulation and experimental results are presented.

A. Mesemanolis, C. Mademlis, and I. Kioskeridis in the fourth paper develop two optimal controllers for squirrel cage induction generator (SCIG) based WECS. The generator electric loss is minimized by the proposed minimum electric loss (MEL) controller and WECS efficiency is maximized by the MPPT controller. Experimental results are presented to demonstrate the effectiveness and performance of the optimal controllers with fast dynamic performance and cost-effectiveness.

The fifth paper is by R. Cisneros, F. Mancilla-David, and R. Ortega. Their paper is focused on small-scale PMSG-based single-phase wind turbines with restricted control authority. A nonlinear, passivity-based controller with high performance is designed based on detailed modeling and energy function with involved theoretical analysis. Simulation test results show that the controller can ensure asymptotic convergence to the MPPT power, regulated dc link voltage and desired grid power factor.

The sixth paper by S. Rodrigues, R. Teixeira Pinto, P. Bauer, and J. Pierik addresses one important aspect of large off-shore wind turbines – the optimal control of multiterminal dc (MTdc) network. Using the offshore transnational grid in the North Sea as an example, this paper develops an evolutionary strategy called covariance matrix adaptation (CMA) to obtain optimal dc power flows inside the offshore network. A distributed voltage control (DVC) strategy is proposed to achieve the power-flow control, which is tested in a dynamic simulation model.

The seventh paper is by Y. Cho, G. J. Cokkinides, and A. P. Sakis Meliopoulos, in which a new modeling methodology for power electronic converters is developed. The method is based on model quadratization and quadratic integration (QMQI). Compared to trapezoidal integration, this method is more numerically stable, robust, fast, and accurate for simulation of complex mixed power systems with nonlinear components and switching subsystems. Detailed theoretical analysis on stability characteristics of the method is presented. The advantages of the QMQI method are demonstrated by two numerical simulation examples of complex power electronics intensive system.

The eighth paper is by Irving P. Girsang, J. S. Dhupia, E. Muljadi, M. Singh, and J. Jonkman. Their paper is focused on high fidelity wind turbine drivetrain model which is integrated into the FAST wind turbine model developed by the U.S. National Renewable Energy Laboratory (NREL). Based on the possible resonant excitations predicted by the model, a novel controller in the power converters is developed to avoid excessive drivetrain stress through the proposed Virtual Inertia Controller (VIC). Simulation results are presented to demonstrate the advantages of the integrated model and the VIC.

The ninth paper is by G. Mandic, A. Nasiri, E. Ghotbi, and E. Muljadi, which develops energy storage solution to smoothen the fluctuation in output wind power. Lithium–Ion Capacitor Energy Storage is used in this study due to the higher energy and power density. Wind energy conversion system including wind turbine control structure, energy storage, power converters, and output power smoothing control is modeled in Matlab. An experimental scaled-down model is built to demonstrate the effectiveness of the energy storage based control system.

The tenth paper is by J. Han, S. Khushalani Solanki, and J. Solanki. A coordinated predictive control system is developed for a micro grid consisting of a wind turbine and battery energy storage system. The proposed supervisory controller performs well for the micro grid under both islanded operation model and grid-connected mode. MPPT control is achieved under changing wind speed and load conditions. Extensive simulations are conducted to test the coordinated control strategy.

The eleventh paper by Y. Zhang, J. Bank, *et al.* develops a method to estimate the equivalent inertia of wind turbine generators based on synchrophasor measurements. Center of bus angles (CBA) based angle instability detection method is proposed for application in power systems with high wind power penetration. The effectiveness of the method is demonstrated with simulation results.

I would like to thank the Editor-in-Chief Dr. Don F. Tan for his persistent assistance and guidance during the entire process of this Special Issue. I am grateful for all the Guest Associate Editors who have devoted a lot of effort. My thanks also go to all the reviewers for their timely efforts to ensure quality of all the papers in this special issue. Last but not least, I must thank all the authors for their original contribution to the important field of wind energy conversion systems. Finally, I would appreciate the constant support from Marlene James and Kristin Falco.

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David Wenzhong Gao (M'02–SM'03) received the M.S. and Ph.D. degrees in electrical and computer engineering, specializing in electric power engineering, from the Georgia Institute of Technology, Atlanta, GA, USA, in 1999 and 2002, respectively.

He is an Associate Professor of Electrical and Computer Engineering and Director of Renewable Energy and Power Electronics Laboratory at the University of Denver, Denver, CO, USA. He has conducted extensive research in areas of power and energy systems including renewable energies, distributed generation, smart grid, power delivery, power electronics application, power system protection, power system restructuring, and hybrid electric vehicles. He has published more than one hundred technical papers in international journals and conferences. He has coauthored a book entitled "Modern Hybrid Electric Vehicles," published by John Wiley & Sons in United Kingdom. His research has been funded by many funding agencies and sponsors including US National Science Foundation, US Department of Energy, National Renewable Energy Laboratory, Argonne National Laboratory, Oak Ridge National Laboratory, US Army Research Office, US Office of Naval Research, Tennessee Valley Authority, US Electric Power Research Institute. In 2009, he won the U.S. National Science Foundation CAREER award for wind power research. He received the Best Paper Award in the Complex Systems Track at the 2002 Hawaii International Conference on System Sciences (HICSS), Jan. 2002.

Dr. Gao currently serves as an Editor for the IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, an Associate Editor for the IEEE JOURNAL OF EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS, and he has been an active Reviewer of leading journals and conferences such as the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, the IEEE TRANSACTIONS ON POWER ELECTRONICS, the IEEE TRANSACTIONS ON SMART GRID, the IEEE TRANSACTIONS ON ENERGY CONVERSION, the IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, the IET RENEWABLE POWER GENERATION, the IEEE TRANSACTIONS ON POWER DELIVERY, the IEEE TRANSACTIONS ON POWER SYSTEMS; IEEE Vehicular Power and Propulsion Conference (VPPC), IEEE Power and Energy Society General Meeting. He currently serves as the Secretary of IEEE Power Electronics Society Denver Section. He teaches courses such as Renewable and Efficient Power and Energy Systems, Power Generation, Operation and Control, Power System Protection. He has been active in various technical committees of IEEE societies and conference organizing committees. He served as General Chair to host 2012 IEEE Symposium on Power Electronics and Machines in Wind Applications (PEMWA) in Denver, CO, USA. He was a Technical Cochair for IEEE Vehicular Power and Propulsion Conference, held in Dearborn, MI, USA, September 7–11, 2009. He was also a Technical Program Cochair in the Organizing Committee of 2013 IEEE GreenTech Conference held in Denver, April 2013. Dr. Gao has been invited to serve on the grant review panel for many funding agencies including the U.S. National Science Foundation, the U.S. Department of Energy, and the Natural Sciences and Engineering Research Council of Canada.