UWM RESEARCH FOUNDATION

Technology Overview

# New Energy Storage Technologies and Power Converter Topologies for Wind Turbines

## OTT ID# 1195

### TECHNOLOGY

The focus of this innovation is a new topology and control technique for energy storage utilization to provide short-term support for wind energy and mitigate the mechanical stress on wind turbine gearboxes. Dr. Nasiri has utilized ultracapacitors (supercapacitors or double layer capacitors) as an energy storage element on the DC bus of a full four quadrant power conversion system or doubly fed induction generator system. He has designed an algorithm to (i) pull mechanical power surges off the drivetrain and into the Lithium-Ion Capacitors for dispatch to the grid and (ii) support the grid and protect the turbine during power system transients (iii) provide support for wind turbines against transient grid low voltage conditions. The immediate benefit of the proposed topology is less mechanical wear, higher efficiency, and lower cost as well as improvement of power system transient stability.

The current and anticipated growth of wind energy will soon exceed the current capabilities of the electric grid to provide the integration services required for reliable system operation, and there is a need to explore innovative solutions for continuing reliable operation with the most economic integration of additional wind energy. The main drawback of wind energy systems are the power fluctuations. This fluctuating power creates torque pulsation, voltage and frequency oscillation, and grid stability issues. Due to the large inertia of wind turbines, the short term (high frequency) power fluctuations are directly converted into torque fluctuations on the shaft. These torque fluctuations create huge amounts of stress on turbine gear box. In addition, the wind speed variations are also translated into power fluctuations and consequently voltage variations at the wind turbine output. It is anticipated that several regulations will be implemented and applied to the wind industry to limit the wind farm power fluctuations and their power ramp rates to protect the utility grid.

### FEATURES/BENEFITS

- **Less stress** - Gearbox stress and mechanical wear is reduced during wind gusts and grid disturbances
- **Grid support** - Improved power system stability during transient dynamics by power smoothing and power ramp control
- **LVRT protection** - The developed system provides protection for the turbine during grid low voltage conditions
- **Higher efficiency** – Additional power conversion stages are avoided for ultracapacitor integration
- **Lower costs** – Less maintenance for replacement of gearboxes and generators; lowers and defers power distribution and transmission costs

### INTELLECTUAL PROPERTY

U.S. Patent 8,860,236.

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## MARKETS

Gearbox reliability and maintenance is one of major concerns of wind industry. The cost to replace gearboxes and generators is a high-cost item – they must be removed by an overhead crane at a cost often exceeding $15,000/day. Replacement gearboxes cost $100,000 to $200,000 and replacement generators cost $250,000 to

$750,000, depending upon MW size. As the wind farm industry enters the next 5 years of rapid growth driven by economic stimulus policies, it is expected that more than 80% of the existing wind turbines will need significant overhaul due to premature wear-out of the mechanical components.

This innovation provides an economical solution to support the grid against wind power fluctuation, high wind power variation rates, and low voltage ride through. Models, analytic tools, and practices have generally not been adapted to address large quantities or large dynamic changes of wind velocity. As wind energy penetration increases over the next several years in the United States, the high maintenance costs will spur investigations into cost-mitigation approaches such as that designed by Dr. Nasiri. The increased efficiency and lower cost of this system is a valuable design which will aid in making wind power more competitive with the traditional sources of energy production.

## INVENTOR

Adel Nasiri

Dr. Adel Nasiri received his Ph.D. degree in electrical engineering specializing in power electronics and motor drives from Illinois Institute of Technology, Chicago, Illinois, in 2004. He worked for Moshanir Power Engineering Consultants Co. from 1997 to 2001. After receiving Ph.D., he worked for Baxter Healthcare Corporation and For Health Technologies, Inc. before joining the Electrical Engineering and Computer Science (EECS) Department of University of Wisconsin-Milwaukee in August 2005. His research interests are power electronics and electronics motor drivers and their applications in renewable energy. He has published numerous technical journal and conference papers on related topics. He also holds two patent disclosures and one filed provisional patent. He is the primary investigator on many industry and federally funded research projects. He is currently the chair of IEEE IES/IAS Milwaukee Section, Associate Editor of International Journal of Power Electronics, Editorial Board Member of Journal of Power Components and Systems. He is also a member of IEEE Industrial Electronics, Power Electronics, Power and Energy, Industry Applications, and Vehicular Technologies Societies.

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