ECE 445 Wind Turbine Generator System Evaluation

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1 Project Description

The main objective of this project is to design a controllable electrical generator system that is well-suited for small-scale (1-10 kW) wind turbine power generation. In addition to controlling the generator system (electric machine plus associated power electronics) to enhance power generation, we hope to use generator control as a means to mitigate structural vibrations in the turbine tower. This strategy may provide a means to reduce the cost of the turbine tower. Tower design is outside the scope of the project. Battery charging properties should be considered in this project.

In this project several promising generator system configurations should be identified and characterized. Several different electric machines should be evaluated. A high-performance configuration (based on simulation results) will then be selected for physical implementation and hardware-in-the-loop (HIL) testing at a lab scale. The system selected should be low-cost, but also provide significant control flexibility to enhance power generation and structural vibration mitigation performance. This project is part of a larger research effort focused on reducing the cost of small-scale wind energy systems.

2 Background

Economic performance of wind energy systems generally improves as spatial scale increases. Utility-scale horizontal axis wind turbines (HAWTs) achieve levelized cost of energy (LCOE) values that are competitive with conventional electrical energy sources. For a variety of reasons a utility-scale turbine may not be a practical option in some situations, but a small-scale turbine is viable. Economic performance of small-scale turbines, however, is low, and their use is often hard to justify. Companies that produce such turbines often struggle to be profitable. In the larger project, we are seeking to utilize creative new system design and control strategies to improve LCOE of small-scale turbines. Identifying a generator system that provides good power generation performance, appropriate torque control properties, and does so at low cost would help achieve this larger objective.

3 Expected Deliverables

1. Design requirements to serve as a basis for comparison
2. Identification of several promising generator system architectures
3. Quantitative evaluation of candidate architectures (simulation-based) in a way that supports fair comparison with respect to overall system performance
4. Lab-scale physical implementation of a candidate architecture that is identified as most promising. Experimental testing and characterization of this architecture.