WindSTAR
Wind-Energy Science, Technology, and Research
Industry/University Cooperative Research Center

Maximizing Wind Power Generation by Extremum Seeking

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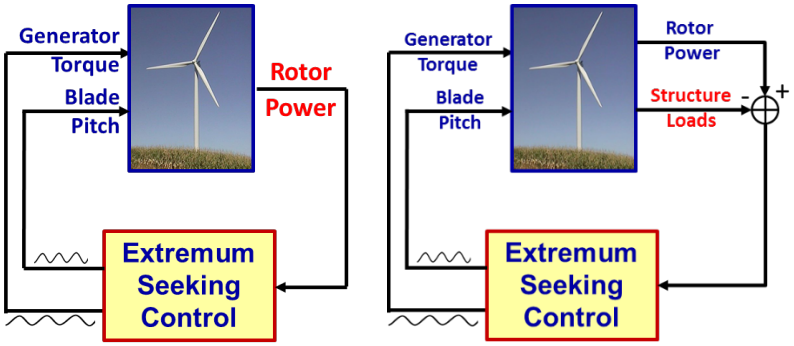
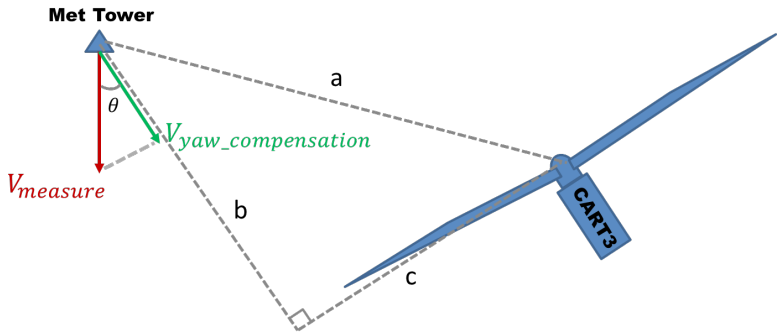
During the first year (2014-2015) of project E2-14, we started by designing the ESC controller and evaluate the performance through simulation study. Then, through collaboration with NREL, the real-time controller codes for ESC based Region-2 controller for NREL's CART3 wind turbine were implemented and tested on CART3 wind turbine. By the end of Year 1, some preliminary tests of the torque-gain ESC had been carried out. The testing results demonstrated promising potential for the torque-gain ESC in achieving higher power yield as compared to NREL's baseline controller.

During Year 2 (September 2015 ~ August 2016), we completed CART3 tests for three ESC control scenarios, i.e. the Torque-gain, Blade-pitch and Two-input (Torque-gain + Blade-pitch) ESC. For all these scenarios, the proposed ESC strategy yielded significant improvement in energy capture with small to mild increase in fatigue loads.

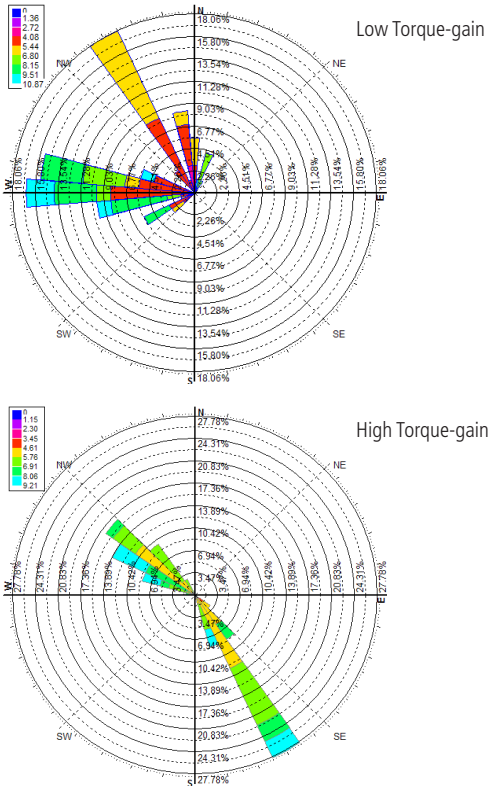
Another aspect of work in Year 2 was the analysis and control solution regarding the large increase in structural loads that had been observed under certain operation scenarios in the initial simulation study during Year 1. In Year 2, we studied this issue in further detail. The analysis shows that the large load increase is due to the excitation of the tower vibration mode at 0.88 Hz. To avoid this excitation, NREL's CART3 control scheme is designed to incorporate a hysteresis loop for the torque control around the critical rotor/generator speed that corresponds to the 0.88 Hz tower structural mode. By reducing the dwelling time near the critical rotor speed/generator speed, the mode excitation is avoided. However, this method requires the knowledge of the critical speed a priori. By introducing the load feedback into the input of ESC, in addition to the rotor power feedback, a multi-objective ESC strategy is formulated, which can maximize the power production without introducing too large load increase. The simulation study demonstrated that the effectiveness of the examined method.



ESC based region-2 controllers with and without load reduction. Without load reduction (left). Multi-objective ESC with load reduction (right).



Wind measurement at Met Tower 4.2 near CART3.



Wind roses (plotted using Hydrognomon [10]) for CART3 testing of the torque-gain ESC and comparative scenarios.

PROJECT ID: E2-14