System ID Modern Control Algorithms for Active Aerodynamic Load Control and Impact on Gearbox Loading*

Dale Berg, David Wilson, Brian Resor and Jon Berg
Sandia National Laboratories†
P.O. Box 5800, MS-1124
Albuquerque, NM USA
deberg@sandia.gov
dwilso@sandia.gov
brresor@sandia.gov
jcberg@sandia.gov

Thanasis Barlas
DUWIND, Delft University of Technology
Kluyverweg 1, Delft, Netherlands
a.barlas@tudelft.nl

Ashley Crowther and Chris Halse
Romax Technology Ltd.
Rutherford House
Nottingham Science & Technology Park
Nottingham,NG7 2PZ
England
Ashley.Crowther@romaxtech.com
Chris.Halse@romaxtech.com

Abstract

Prior work on active aerodynamic load control (AALC) of wind turbine blades has demonstrated that appropriate use of this technology has the potential to yield significant reductions in blade loads, leading to a decrease in wind cost of energy. While the general concept of AALC is usually discussed in the context of multiple sensors and active control devices (such as flaps) distributed over the length of the blade, most work to date has been limited to consideration of a single control device per blade with very basic Proportional Derivative controllers, due to limitations in the aeroservoelastic codes used to perform turbine simulations. This work utilizes a new aeroservoelastic code developed at Delft University of Technology to model the NREL/Upwind 5 MW wind turbine to investigate the relative advantage of utilizing multiple-device AALC. System identification techniques are used to identify the frequencies and shapes of turbine vibration modes, and these are used with modern control techniques to develop both Single-Input Single-Output (SISO) and Multiple-Input Multiple-Output (MIMO) LQR flap controllers. Comparison of simulation results with these controllers shows that the MIMO controller does yield some improvement over the SISO controller in fatigue load reduction, but additional improvement is possible with further refinement. In addition, a preliminary investigation shows that AALC has the potential to reduce off-axis gearbox loads, leading to reduced gearbox bearing fatigue damage and improved lifetimes.

† Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.