Comparison of Feedback and Ideal and Realistic Lidar-Assisted Feedforward Individual Pitch Control

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Abstract

Individual pitch control (IPC) for load reduction has been discussed for almost two decades [1]. Different feedback (FB) approaches dominate. Occasionally lidar-assisted feedforward (FF) IPC has been investigated in recent years [5-8]. Both IPC strategies need additional sensors in unequal price categories. For future industrial application a comparison of both strategies regarding their load reduction is of interest to evaluate whether the investment in a lidar system is worth its much higher price.

Lidar simulation:

- Volume measurement included
- Realistic measurement trajectory close to Wind IrisTM:
  - 5 points on a circle
  - 6 simultaneous measurement distances
- Trajectory optimized by means of SWE’s analytical model (AM) [9]
- Direct accounting of wind evolution by filtering the reconstructed wind field characteristics with a first order Butterworth filter (BWF)
- Filter design via transfer function from rotor to lidar area derived by SWE’s AM

- Eliminates unrealistic high frequency fluctuations due to application of Taylor’s hypothesis of frozen turbulence in simulation
- Eliminates frequencies that are not correlated for the specific rotor and lidar measurement configuration

Lidar Assisted Cyclic Pitch Feedforward Control

The inhomogeneous wind field is modelled by a horizontal mean wind speed \( \bar{v}_c \), a linear horizontal \( \Delta \bar{v}_c \), and a linear vertical shear \( \Delta \bar{v}_h \) as an average over the rotor or measuring area. A static compensation of the shear effects is designed.

Parametrization via a simplified model of turbine aerodynamics:

Optimal blade angles \( \beta_n \) for each azimuth angle \( \varphi \) are determined by stationary simulations and simplified afterwards.

Structure of the feedforward control loop:

- No FB IPC added to FF IPC
- FF IPC only used above rated wind speed
- Time shift \( T_B \) by predictive measurement
- Time shift \( T < T_B \) to compensate pitch dynamics and filtering

References of Full Paper


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