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Semiactive Control for Floating Offshore Wind Turbines Subject to Aero-hydro Dynamic Loads

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Abstract. Wind and wave dynamic loads might cause undesirable vibrations that affect the structure integrity and system performance of floating offshore wind turbines. This paper addresses the problem of dynamic load mitigation by using semiactive control techniques with the tuned liquid column dampers placed on the turbine's tower. The control law is formulated based on the mixed H_2/H_∞ methods for ensuring the system stability and reliability. Furthermore, the proposed controller only uses output feedback so as to avoid the dependence on the knowledge of the states of the system.

Key words

Floating wind turbines, offshore wind energy, semiactive control, mitigation of dynamic loads and vibrations, liquid column dampers.

1. Introduction

In recent years, offshore wind energy becomes one of the fastest growing powers in the field of renewable energy [1]-[2]. Although the installation and operation cost of offshore wind power is still more expensive than that of onshore wind power, an offshore wind farm situated sufficiently far away from the coast (e.g. >25 km) can generate more wind power and will have a longer operation life since the winds are stronger and more consistent than those on or near the coast. It can also avoid some major problems of the traditional wind farms like the visual and noise impacts and potential damage to wildlife. From the technical point of view, it is difficult to anchor the wind turbines directly on the seabed in the areas where the water depth is greater than 50 meters. Thus, new constructive solutions based on floating support substructures are proposed, which need a highly complex technological innovation. In June of 2009, the first floating offshore wind turbine of the world was installed by Statoil-Hydro and Siemens off the coast of Karmøy, Norway.

Wind turbines are highly flexible machines operating in stochastic environments. One of the main challenges is to reduce the fatigues of a floating offshore wind turbine so as to guarantee its proper functioning under the constraints imposed by the floating support substructures subject to a greater range of motion than that of the conventional fixed ones. Due to the coupling effects of the wind and wave dynamics, we should consider the effect of the floating support substructure motion on the strength of the blades and shafting, and the inertia force induced by the combined rotational, translational and angular motion of the blades. Thus, an exhaustive study should be done to model the wind turbine environments and obtain their response to environmental forces during operation. The application of advanced control strategies to wind turbines is crucial for maximizing the energy captured from the wind [3] and minimizing the dynamic loads of these machines for the extension of their fatigue life [4]-[5].

This paper addresses the problem of designing semiactive controllers to mitigate the dynamic wind and wave loads on floating offshore wind turbines, which might cause undesirable vibrations that affect the structure integrity and system performance. The output feedback control strategy is proposed to avoid the dependence on the knowledge of the states of the system. The mixed H_2/H_∞