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Time Domain and Frequency Domain Characterization of Floating Offshore Wind Turbine

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ABSTRACT

A large number of offshore wind farms with fixed foundation have been built in Europe with the relatively state-in-art techniques. Much of the offshore wind source potential in United States, China and other counties is available in the water depth more than 50 meters, where floating offshore wind turbine shows their economic potential. Comparing with the onshore system, the offshore wind turbines sustain more complicated environment conditions with stochastic wind and wave. The floating offshore wind turbine (OWT) is still in their early stage. As a whole system, OWT is designed and analyzed using simulation tools capable of predicting the coupled wind-inflow, aerodynamic (aero), control system (servo), and structural-dynamic (elastic), incident waves, sea current, hydrodynamics (hydro), and foundation dynamics of the support structure in a coupled simulation environment. The so called aero-hydro-servo-elastic modeling is needed. In this work, the three-blade 5MW upwind wind turbine, which is the basic model under IEA Annex 23 Subtask 2 Offshore Code Comparison Collaboration (OC3) project, is supported by an OC3-Hywind spar buoy platform. The platform is connected by three mooring lines to the seabed. Coupled aero-hydro-servo-elastic model with full flexible components including the platform, blades, tower and drivetrain is used in the simulation by the open source code. Several primary design load cases with different wave and wind condition are investigated. The natural frequency, damping ratio, the statistic and frequency domain responses of the system are included.

KEY WORDS: offshore wind energy; turbulence intensity; floating foundation; RAO; frequency domain.

ABBREVIATION

CM: Center of Mass
COB: Center of Buoyancy
DLC: Design Load Case
DLL: Dynamic Link Library
DOF: Degree of Freedom
FAST:Fatigue, Aerodynamics, Structures and Turbulence
IEA: International Energy Agency
NTM: Normal Turbulence Model
NSS: Normal Sea State
OC3: Offshore Code Comparison Collaboration
OWT: Offshore Wind Turbine
SWL: Still Water Level

NOMENCLATURE

A_{ij} (i,j) component of the impulsive hydrodynamic-added-mass matrix

B_{ij}^{Linear} (i,j) component of the additional linear damping matrix

C_D Normalized hydrodynamic viscous drag coefficient

$C_{ij}^{Hydrostatic}$ (i,j) component of the linear hydrostatic restoring matrix from the water-plane area and COB

C_{ij}^{Lines} (i,j) component of the linear restoring matrix from all mooring lines

D Diameter of cylinder in Morison's equation

$F_i^{AddDamp}$ ith component of the total loads on the platform from additional damping

$F_i^{Hydrostatic}$ ith component of the total loads on the platform loads from linear hydrostatics

F_i^{Lines} ith component of the total loads on the platform from all mooring lines

$F_i^{Lines,0}$ ith component of the total mooring line loads on the platform in its undisplaced position