Real-Time Hybrid Model Testing of Floating Wind Turbines

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Numerical Setup

- Software: SIMA (by MARINTEK)
- Hydrodynamics, kinetics and mooring dynamics modeling
- Actuators (Motor+spring+wheel+wire) modelled by a winch + winch controller + elastic cable.
- Wind turbine aerodynamics modeling for verifcation of the numerical model
- Real-time communication with the ReaTHM testing controller

The ReaTHM controller can communicate with either the physical or the numerical setup, at its option. Most of its features are compatible with both setups with only minor changes in the code.
The numerical setup provides the flexibility necessary to develop a complex ReaTHM testing project. It is also a simulation tool able to reproduce the environment of the ocean wave basin at no cost.

Real-time hybrid model (ReaTHM) testing in NOWITECH model tests

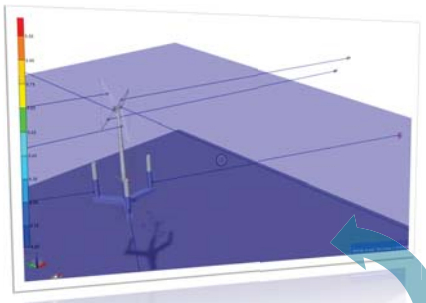
- CSC braceless semi-submersible, scale 1/30, in MARINTEK's ocean wave basin
- NREL 5MW turbine, physical tower with correct mass properties.
- Actuated wind forces. No physical wind, no rotor, but a set of 6 actuators applying in real-time the thrust force, generator torque and pitch and yaw moments calculated by NREL's AeroDyn from a turbulent wind field and online measured motions.
- No Froude-Reynolds scaling conflict, controlled wind field and aerodynamic loads, flexible inclusion of the rotor and the generator torque/blade pitch controllers

Verification of kinematic modeling

Numerical model verification

Verification of emergency stop procedures

Study of the effect of time delays



Numerical setup

Physical setup

Disturbances

x 6

Force transducer, Thin wire, Wheel, Spring, Servomotor

Accelerometers, Gyrometers

HBM

Router/ logger

CANopen

Amplifier

QUALISYS

Optical measurement system

Hydrodynamic loads

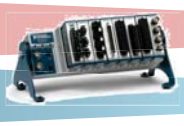
Java

ReaTHM testing controller

UDP

NATIONAL INSTRUMENTS

UDP



UDP

EtherCAT

Hardware

Software

LabVIEW

Communication loop

Motion observer loop

Delay compensation

Velocity observer

Filter

$\frac{d}{dt}$

$\int dt$

Position

Acceleration

Rate

Force observer loop

Model

Force

Observer

Numerical model loop

Velocity, rate, position

Wind Field

Time

t

$U_i(t)$

DLL

Structure kinematics

Rotor dynamics

ξ

Ω

Blade kinematics

u_i, η_i

AeroDyn

f_i

Force integration

τ_{ref}

θ

Wind turbine controller

Q_g

Force commands

F_{ref}

Force allocation

Controller loop

Motor commands

Feedforward controller

Feedback controller

Predicted position

Commanded force

Filtered force