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Advanced WTG testing with Grid- and Wind-HIL-modules

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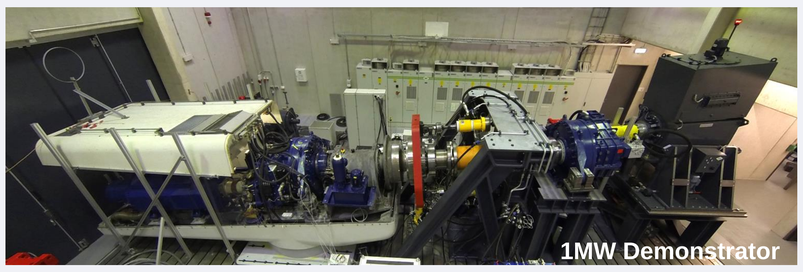
Abstract

Dynamic loads caused by wind and grid effects lead to poorly predictable deformations and complex vibrations in the entire drivetrain. The importance of system tests for wind turbine nacelles and drivetrain components steadily increases, since this approach leads to higher quality and reliability.

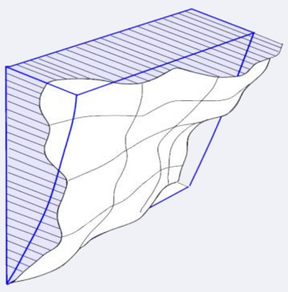


The Center for Wind Power Drives (CWD) at Aachen University successfully developed and validated the multi physical hardware in the loop (HIL) operating mode for full size ground testing with the 1MW test bench demonstrator. Based on the experiences gained during the design and use of the 1MW test bench demonstrator, the HIL environment was ported to a 4MW WTG system test bench.

Objectives

- providing reproducible loads and conditions
- focus on comprehensive functionality
- good observability under real conditions
- analysis of several damage mechanisms with high accuracy
- improvement of existing and future designs

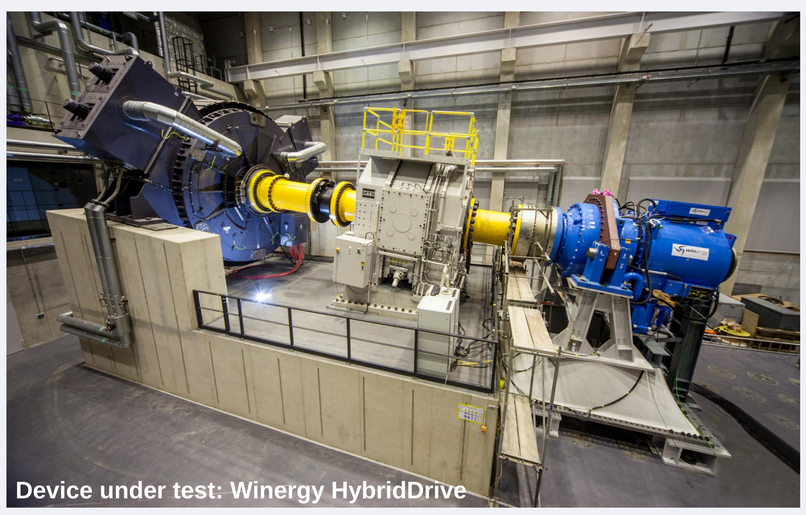
Emulating Wind Loads



An entire **3D wind field** is emulated by the stochastic distribution of average wind speed, turbulence intensity and oblique inflow. Including the structural and aerodynamic properties of the rotor blades, current pitch and rotor speed the wind loads are calculated in real time. The wind field and force calculation is done at the rotor system level.

Backlash Free Loading

To ensure high dynamics the new 4MW WTG system test bench is capable of backlash free load application of the drivetrain including thrust, radial forces, tilt and yaw moments. This setup with direct drive motor and a load application system (LAS) with pre-loaded hydraulic actuators has successfully been proven with the first device under test (see below).

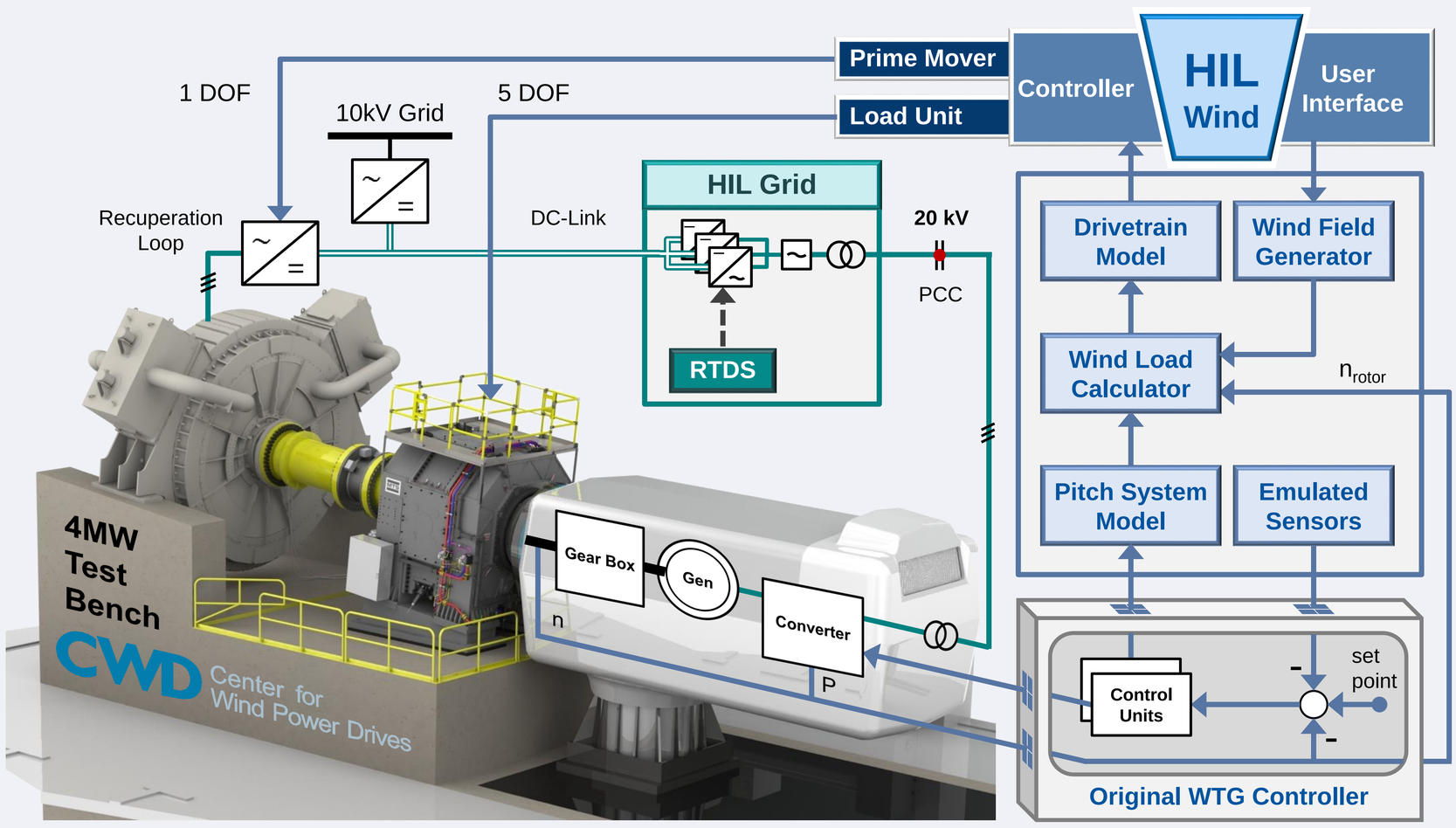


Unique Capabilities

Fault Ride Through Functionality The nacelle is completely integrated into the HIL system. On the grid side, the Real Time Digital Simulator (RTDS) provides advanced FRT test functionality within the HIL environment to examine the FRT performance in many conceivable ways. The FRT grid loads are applied at the Point of Common Coupling (PCC) on system power level by a flexible frequency converter system.

Size does matter While several influences are unaffected by the size, most of the relevant effects like global deformation on local contacts or slipping have to be analysed within full size tests.

The lack of knowledge about the overall system behaviour and the complex interaction of the drivetrain requires particular realistic ground tests of nacelles to solve reliability issues. While field testing of prototypes is too expensive and single component testing not sufficient, full size ground testing remains the only suitable way to increase and improve the development of future wind turbines.



Multi Physical Hardware in the Loop Testing

Great Benefits Beside the accuracy and performance of the LAS, the WTG system test benches focus on the verification, that a full nacelle can be tested inside a multi physical hardware in the loop environment. The HIL control system provides both mechanical and electrical loops.

Within the HIL mode, the input parameters on the rotor side define the wind field in which the nacelle is operating while the independent real-time grid simulation emulates the grid behaviour. Using real-time simulations allows to run the nacelle with its own original controller as used on the tower.

Using the original WTG controller offers the opportunity to analyse strengths and weaknesses of the control strategy while the WTG behaves unaffectedly. The controller itself has a major influence on the loads of the nacelle by controlling the generator, pitch and yaw system.

Results & Conclusion

Realistic WTG Dynamics

The behaviour of the nacelle during various tests on the 1MW test bench demonstrator correlates highly with the original intended control strategy. The evaluation of several design load cases under different wind conditions using the HIL operating mode shows that the dynamic performance of the LAS is adequate to apply realistic dynamic wind loads within the relevant frequency range of 5 Hz. In addition to the HIL system for the aerodynamic loads, a HIL system for the real-time simulation of grid loads and FRT case studies will be integrated into the control system of the 4MW WTG system test bench in 2015.