PO.ID 040c

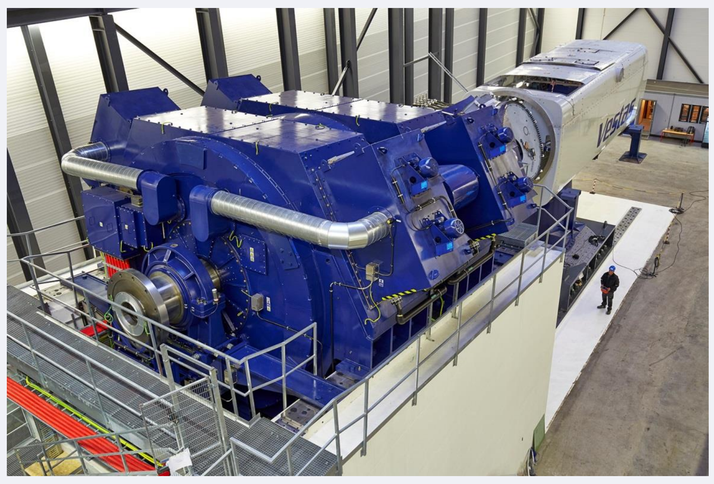
Realistic full scale indoor testing of wind turbine nacelles

Torben Lorentzen, CEO
Lars Stylsvig Rasmussen, Project Manager

Introducing realistic tests

Reliability and shortening the time-to-market are what drive the LORC Test Centre in Denmark.

With the 10 MW nacelle testing centre LORC has taken indoor ground testing of nacelles to a new level, introducing testing of nacelles including the hub. This increases the confidence level compared to traditional indoor testing on the main shaft because the hardware and controllers of the nacelle stay active during testing, and thereby creating a scenario as if the turbine was operation on site.



Objective: gaining full confidence

The objective is to create a realistic and controlled indoor environment in which the turbine nacelle can be tested for control and functionality.

The setup can help determine if the turbine fulfills different grid code requirements, and verify correct control performance during a variety of operating conditions.

In order to gain full confidence the complete electrical system of the nacelle and tower components are connected and operational in the test setup.

Test setup

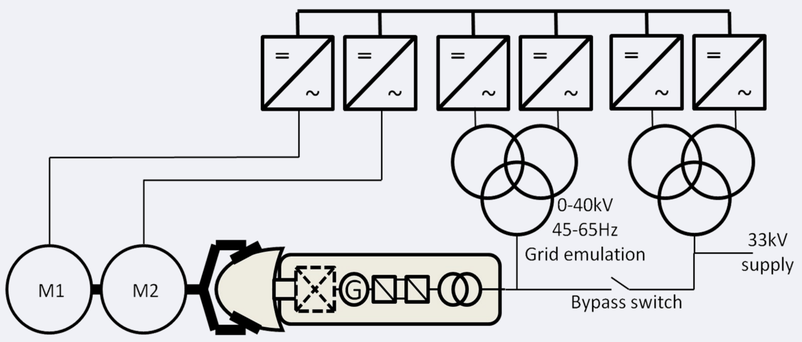
The setup consists of a large direct drive medium voltage motor, which is used to spin the nacelle hub.

Motor data	
Rated Power	13,6 MW
Rated Torque	12 MNm
Rated voltage	3 kV
Weight	App. 300 tn

Between the motor and the nacelle a linked misalignment and torque limiting coupling is placed. It obtains the physical movements that occur when loading the drivetrain of the nacelle.

In case a fatal accident happens in the nacelle or direct drive motor which blocks the driveline, a torque limiter is built into the coupling. It will decouple the inertia of the nacelle and motor to let them spin independently.

The torque limiter can be adjusted for different thresholds levels depending on the size of the nacelle under test.



Electrically the test nacelle can be connected to either a fixed 50Hz; 33kV power supply or a converter based grid emulation 45-65Hz; 0-40kV.

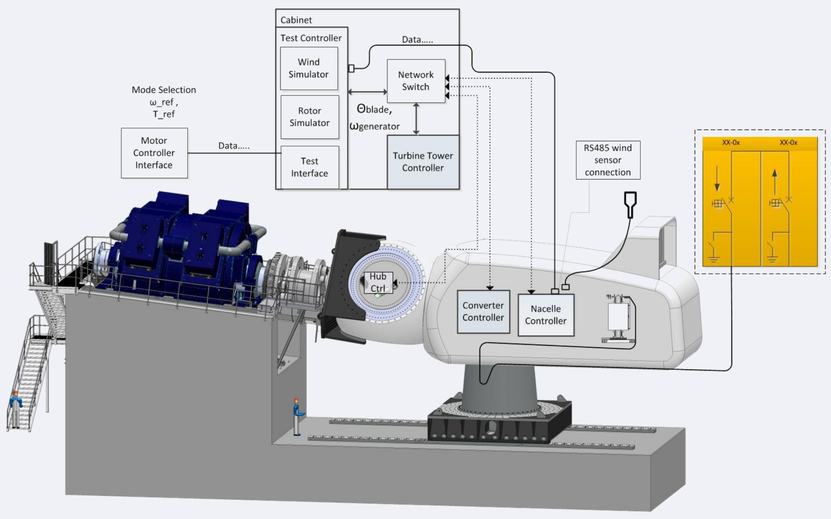
The converter for the grid emulator is connected to the same DC-link as the motor and front end inverter to ensure the power generated by the nacelle is reused in the test setup.

It is possible to program the grid emulator to replicate a variety of grid events, which can be tested at different turbine output power levels.

Torque control mode

In order to ensure the most realistic and correct test results a torque control mode is implemented in the test system.

It includes a wind reference profile for the nacelle, and a torque controller. The controller uses the wind speed, the pitch angle from the hub and the revolutions. From those parameters an analogue torque reference is sent to the motor controller, which then effectively acts as the torque from the wind on a site.



The closed loop torque control makes it possible to replicate specific site events, because any given wind reference profile can be fed into the controller.

The torque mode is used in test cases to evaluate important control features including:

- Startup sequence
- Partial load control
- Full load control
- Emergency stop modes
- Extreme wind events
- Load cases combined with grid fault events

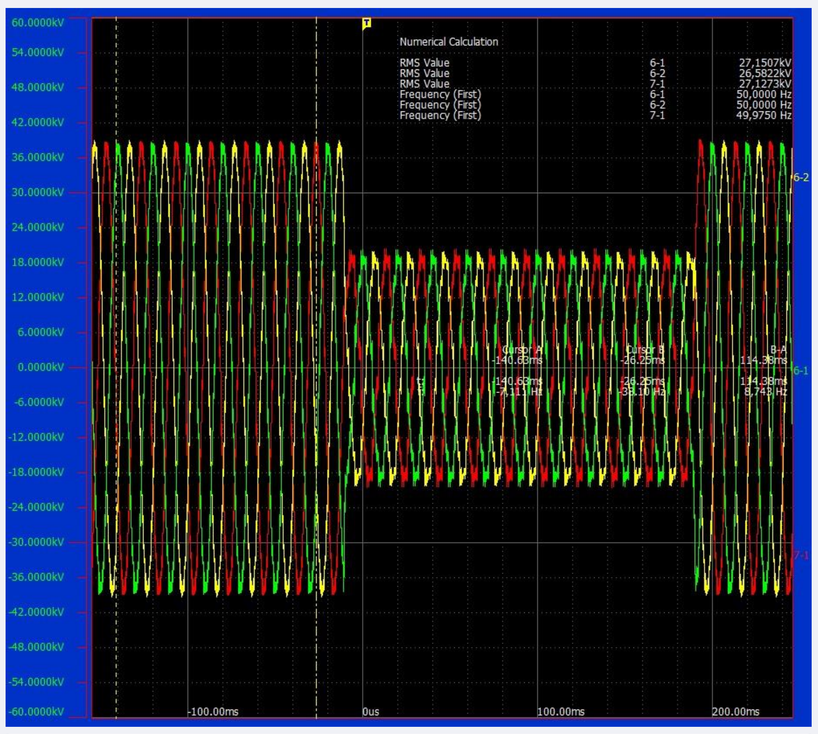
As a part of the test system, a link between the emergency stop system of the nacelle and the emergency stop system of the test bench is established. It ensures correct failure behavior in case either system is activated.

LVRT verification

The grid emulator can be programmed to verify LVRT (Low Voltage Ride Through) performance of the nacelle.

In the torque control mode, not only the electrical system's performance is verified, but also the whole drive train dynamic behavior, because the turbine is operating in a realistic mode, based on the wind profile tested.

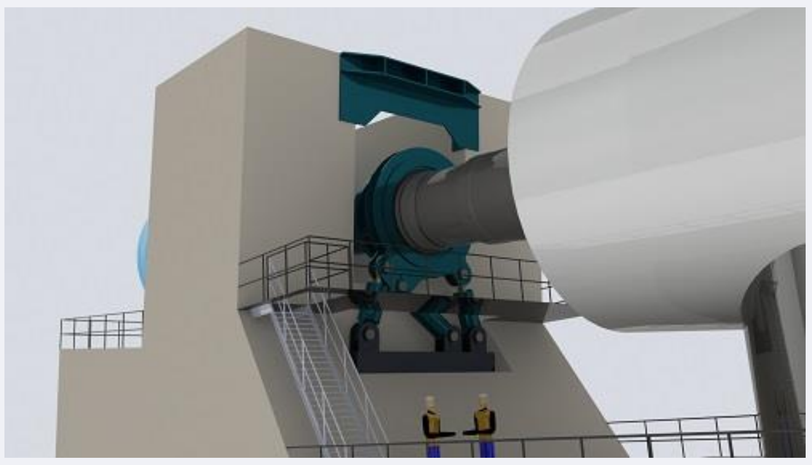
An example of a converter based 200ms voltage dip from 0,8pu to 0,4pu is shown in the data recorder plot.



HALT testing

LORC is currently establishing a second test dock for full scale testing of nacelles. It will perform highly accelerated lifetime testing, HALT, exposing the nacelle under test to full-scale tilt and yaw moments enabling customers to demonstrate 25 years of service life of their turbine.

The capacity of this test rig will also be nacelles with a power output in the 10 MW range.



By reproducing loads the mechanical components inside the nacelle is exposed to stress levels that can be measured accurately by various pieces of measurement equipment, e.g. strain gauges that measure how much a given surface of a given component is either stretched or compressed during testing. Knowing the material properties and knowing the forces and moments applied, it is possible to analyze the stress levels and thereby determine life-time accurately.

Furthermore, since internal components of the nacelle are connected directly or indirectly it will be possible to determine the chain-reaction of the interaction of multiple components when influenced by loads. This is done by measuring and analyzing the paths of loading.

The HALT tester will be operational by end 2016.