With wind turbines becoming larger and larger, the control system has become extremely important – and so has a testing environment for the control system itself. A comprehensive assessment of wind turbine controllers in the lab reduces risks of erroneous implementations in the field and significantly shortens commissioning times.

**Hardware-in-the-Loop Platform**

The Virtual Wind Turbine for Real-Time Controller Testing is a Hardware-in-the-Loop (HIL) simulation platform for the test of wind turbine controllers. It allows for comprehensive, automatic testing of the complete control system: controller software and hardware, including dynamic control as well as supervisory control. In the HIL approach, the dynamics of a wind turbine, as seen by a turbine control system, are simulated in real-time on a standard industrial environment, which emulates all required input signals of the controller and reacts to the controller commands like a real turbine.

**Automatic Testing**

A batch mode provides the automatic processing of a number of load cases, e.g. extreme events and grid faults. Thus, industrial wind turbine controllers are tested systematically under reproducible environmental conditions.
System Overview

The overall testing platform consists of two major parts: A host computer to
- derive the simulation model
- setup and control the simulation process
- display the simulation results, and an industrial PC that runs the real-time simulation of the wind turbine and
- logs the time series of the virtual wind turbine’s outputs.

The original turbine controller, usually a programmable logic controller (PLC) running the dynamic and supervisory control system, is connected to the virtual wind turbine via the original interface, usually a combination of a field bus and analog and digital I/Os.

Wind Turbine Model

A flexible, block oriented modeling approach is used for describing the wind turbine, based on the simulation software package Matlab/Simulink®. The complexity of the model can be easily adapted by adjusting the number of mechanical degrees of freedom and by using subsystem blocks with different levels of detail for aerodynamics, generator system, pitch system etc. Furthermore, the model is closely related to models that are used for control design. This provides a good balance of model complexity: The accuracy has been shown to be similar to other widely used simulation codes like Bladed and Flex5, while the computational effort is low enough to run the model on standard industrial PCs in real-time.

Customization Service

As both the turbines and the controller hard- and software varies with the different manufacturers, we provide
- adaptation of the virtual wind turbine models to particular wind turbines,
- implementation of the virtual wind turbine on various automation hardware, and
- support for the integration of customer-specific features.

Extended Application

The HiL simulation platform is not restricted to the testing of wind turbine controller hardware. Due to the open, modular modeling approach, it can easily be adapted to other applications for HiL-tests of
- blade pitch systems,
- generator systems,
- drive train, and
- wind farm controllers.

Real-Time Implementation

A real-time version of the model is directly compiled from the Simulink-model using the automatic code generation capability of Simulink. Hence, the real-time model can be implemented on wide range of automation systems.