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Power Hardware-in-the-Loop Setup for Power System Stability Analyses

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To accelerate progresses and lower costs of design during development phases, new methods for verifying ideas and inventions have to be developed.

Following challenges are addressed by the authors:

- Development of new testing and validation procedures (PHIL)
- Design of adequate test setups
- Power System Stability testing in laboratories
- PHIL for prospective large scale distributed generation scenarios

Innovative Testbed Design at Fraunhofer IWES

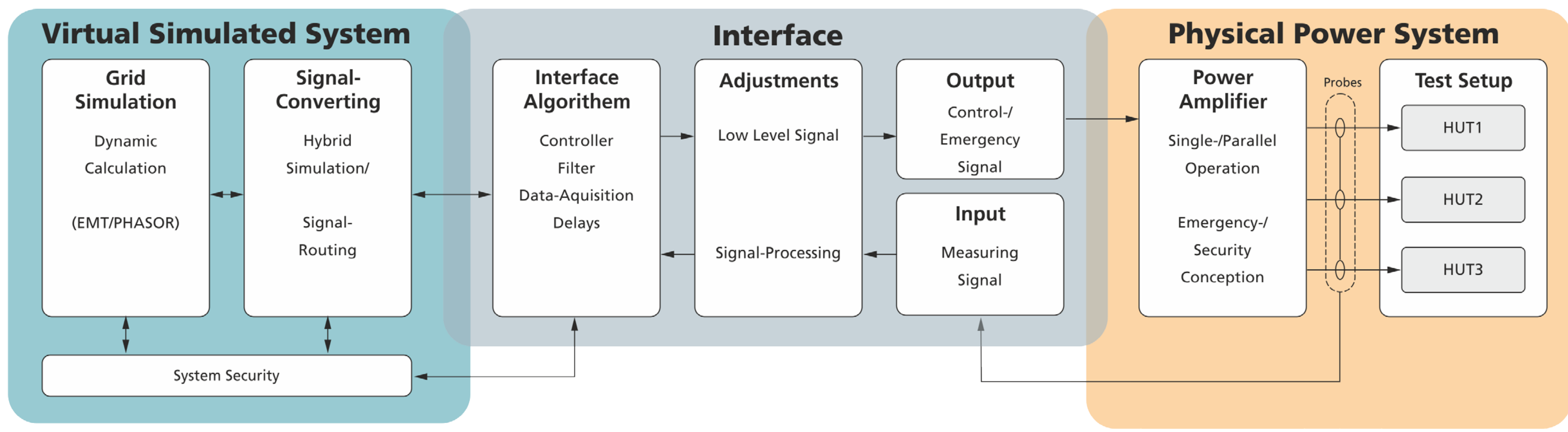
A flexible PHIL test infrastructure was built-up at the SysTec laboratory of Fraunhofer IWES to perform the following:

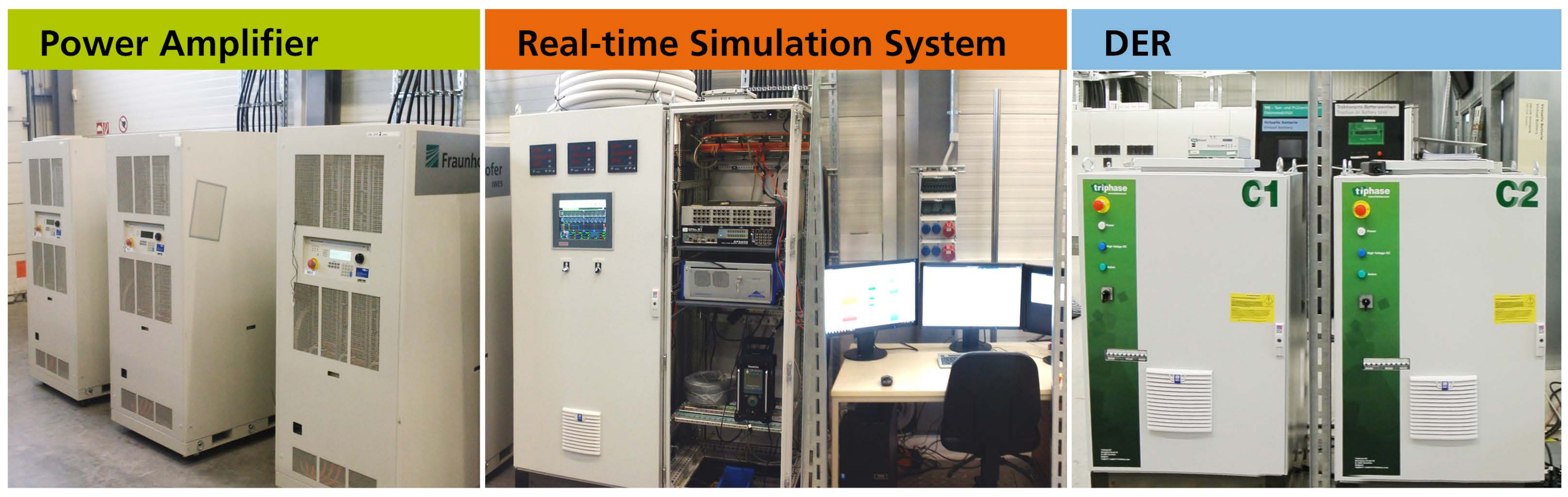
- Lab-testing under close to field test conditions
- Power system studies integrating physical prototypes or »black-box« devices
- Interdependency testing of physical devices in embedded network simulation
- Protection relays testing
- Extensions of physical LV or MV test networks by simulations

Conclusions and Overview

Possible support of PHIL technologies

- Realistic mapping of simulation to the lab-based testing
- Advanced testing of prototypes and innovative methods and technologies
- Large interconnected power systems stability analysis





Power Hardware-in-the-Loop Testbed for Power System Stability Investigations @ Fraunhofer IWES SysTec

Case 1 – Voltage Stability varying Active Power Recovery Rates

First study case investigates power system support of different active power recovery gradients after short term voltage dips (Low-Voltage-Ride-Through events)

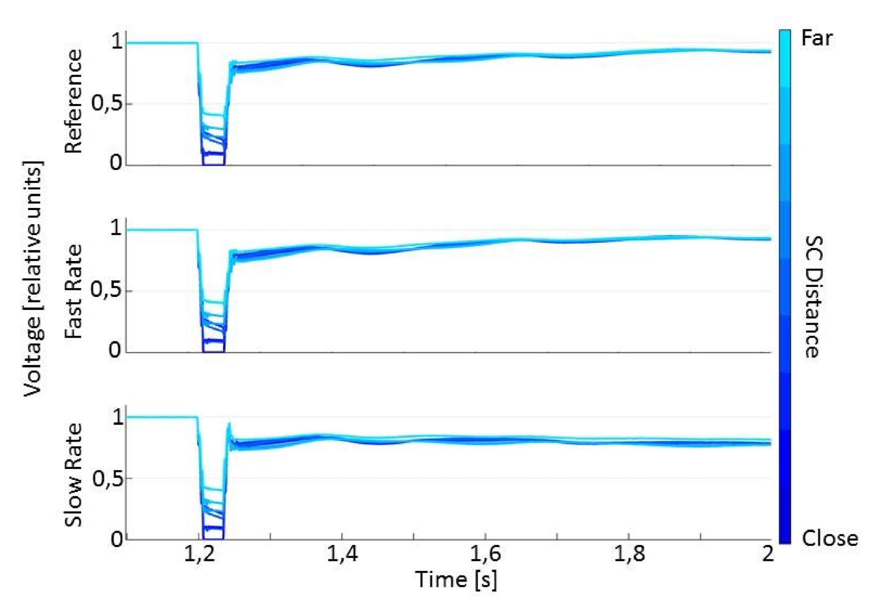


Fig.2 Bus Voltages during different scenarios. Third diagram shows additional voltage drop related to power loss in the system

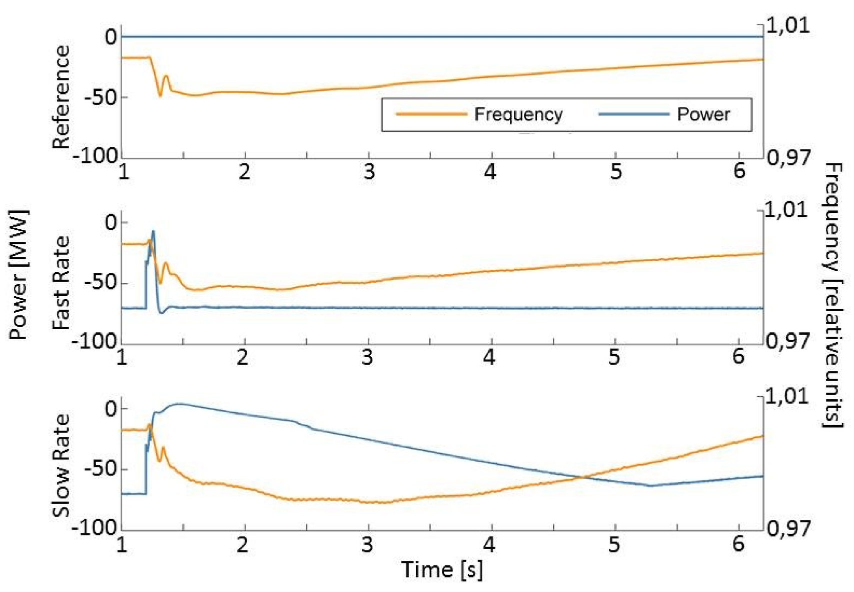


Fig.3 Power injection and system frequency. Third diagram shows frequency rise to instable system conditions

Case 2 – Frequency Stability with Active Inertia Emulation

The second case investigates influences of a developed power electronic inertia controller for wind parks during a load imbalance in the IEEE 9-Bus System simulation.

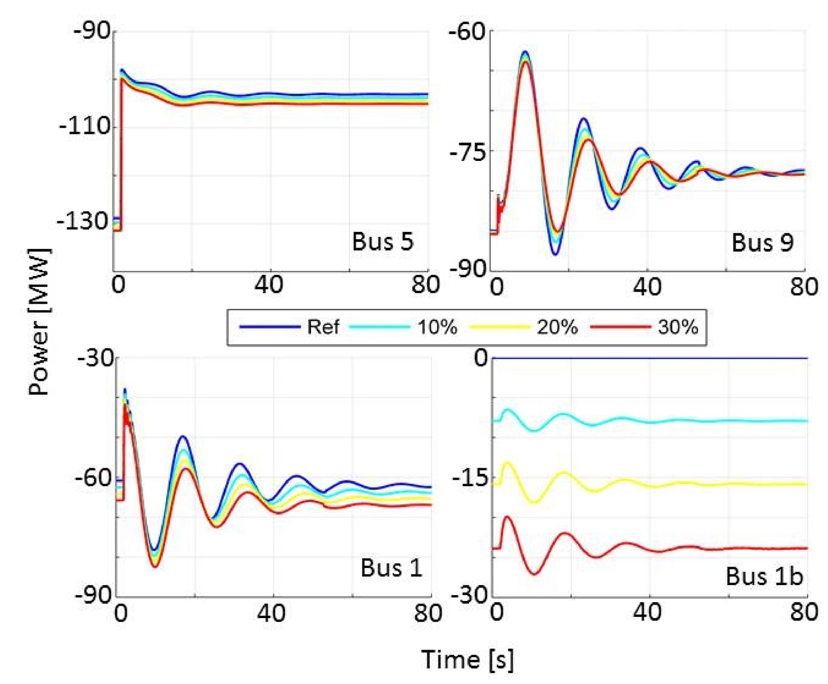


Fig.4 Power flow at several busses. Bus 1b presents injection of wind park (blue reference, red highest contribution)

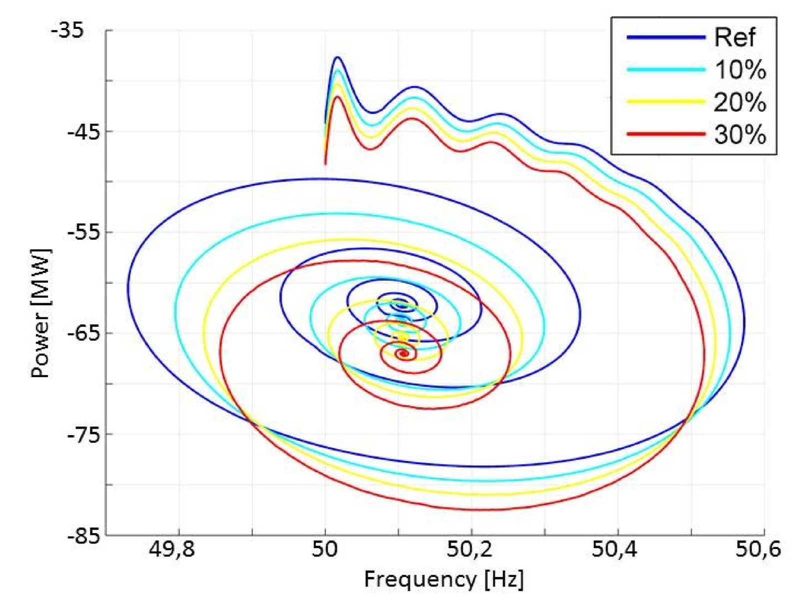


Fig.5 Power over Frequency at Bus 1b. Higher power injection (red) decrease frequency variation bandwidth

Benefits of fast Recovery Rates:

- Faster rates improve short-term voltage stability
- DER can provide fast recovery rates

Virtual Inertia Improves Stability:

- Endorsement of virtual inertia for Power System Stability
- Higher impact/contribution shows higher frequency stability support

PHIL de-risks roll-out of new technologies by enabling reality-close testing in controlled laboratory environments!

DERlab
European Distributed Energy Resources Laboratories

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Supported by the H2020 Programme under Contract No. 654113

We acknowledge the support of our work by the German Ministry for the Environment, Nature and Nuclear Safety and the Projektträger Jülich within the project »DEA-Stabil: Beitrag der Windenergie und Photovoltaik im Verteilungsnetz zur Stabilität des deutschen Verbundnetzes"«(FKZ 0325585). Furthermore this work is partly supported by the European Community's Horizon 2020 Program (H2020/2014-2020) under project »ERIGrid: European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out« (Grant Agreement No. 654113).