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Towards Holistic Testing: Development of a Microgrid Controller

Ron Brandl[1]
Juan Montoya[1]
Maria Nuschke[1]
Diana Strauss-Mincu[1,2]

Contact:
ron.brandl@iwes.fraunhofer.de
Phone +49 561 7294-103

[1]*Fraunhofer IWES*
Institutsteil Energiesystemtechnik
Königstor 59
34119 Kassel / Germany
www.energiesystemtechnik.iwes.fraunhofer.de

[2]*DERlab e.V.*
Königstor 59
34119 Kassel / Germany
http://der-lab.net

Test chain for innovative smart grid developments

Smart grid components and units are being increasingly equipped with functionalities that make them more autonomous in terms of providing grid support. The share of such grid integrated units is increasing and so is the complexity of smart grids. This leads to challenges in terms of ensuring grids stability and security of power supply.

A holistic test chain is introduced as strategy to overcome these challenges and is structured as follows:

1. Simulation-only
2. Controller Hardware-in-the-Loop
3. Power Hardware-in-the-Loop
4. Pure Hardware/Field Test

Advantages of this approach are:

- New control algorithms and procedures can be tested in real-time and in realistic environments
- Efficient and low-cost prototyping is possible
- Products' faults or non-conformities can be detected and solved efficiently
- Cost- and time-intensive field tests can be prevented

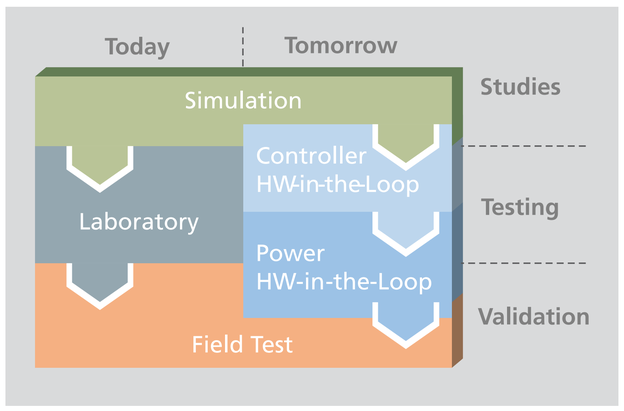
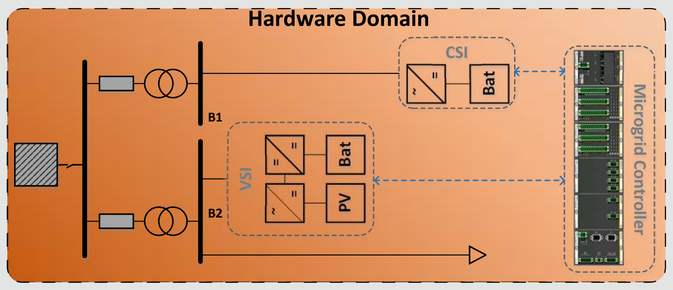


Fig.1: Testing chain with new technologies

VALIDATION

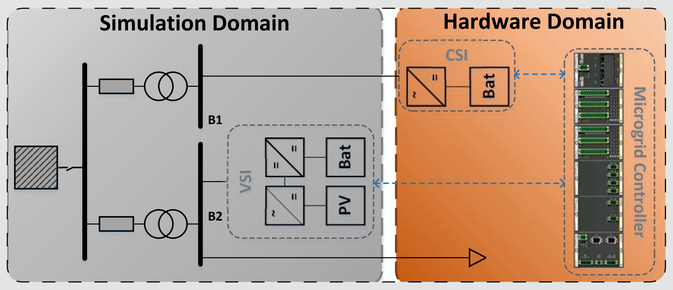
Stage 4: Pure Hardware Validation



… next step,
challenging but well prepared!

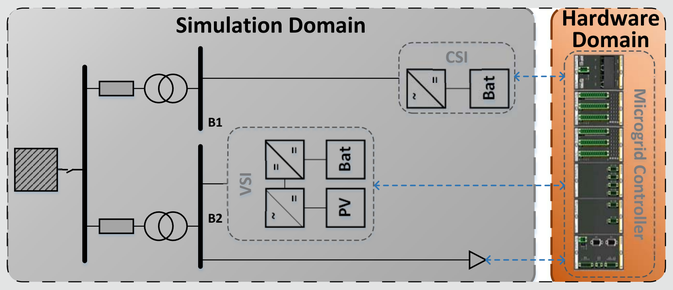
TESTING

Stage 3: Power Hardware-in-the-Loop Testing



- Partial replacement of simulated models by hardware
- Verification of bidirectional communication, DuT and power hardware operation and harmonized performance
- Consideration of all dynamics of the power hardware

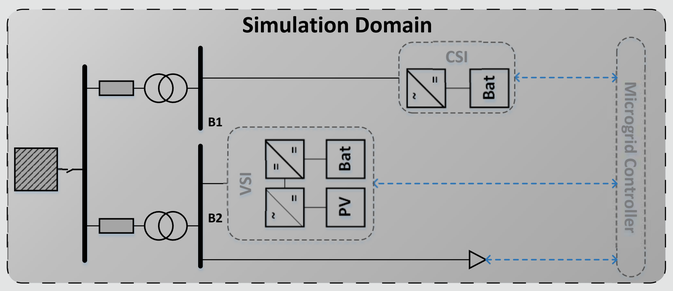
Stage 2: Controller Hardware-in-the-Loop Testing



- Transfer of the Microgrid Controller as Device-under-Test (DuT) onto real hardware
- Verification of stage 1 simulation cases
- Consideration of all dynamics and interfaces of the DuT

SIMULATION

Stage 1: Simulation-only Investigation



- Implementation of required components and control strategies in simulation environment
- Fast execution of various investigations (short-/long-term aspects)
- For long-term analysis system dynamics are not considered

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Comparative results

The results of the different test stages need to be compared in order to validate the performance of the Microgrid Controller. Fig. 2 shows the comparison of profile data of load and PV as inputs and the state of charge (SOC) of two batteries as resulting outputs.

Comparison of stage 1 and stage 2 results :

- Inputs are identical
- Tendency of SOCs and maximum operation time are very similar
- Performance in stage 2 is comparable to stage 1

➔ Units ready for next stage testing.

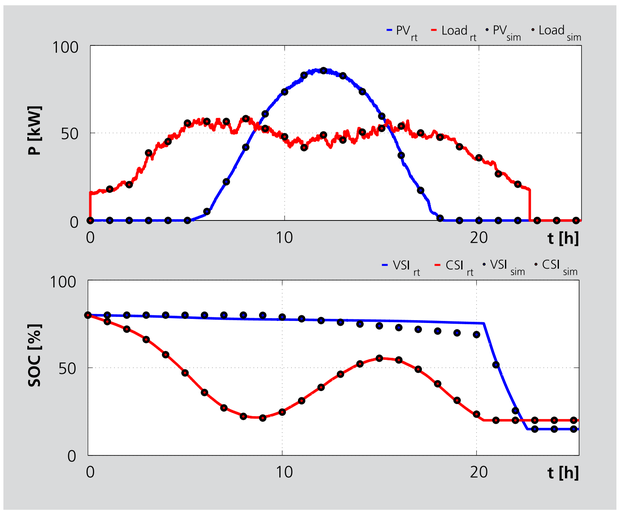

Fig.2: Active power and state of charge of CSI and VSI battery from stage 1 (sim) and stage 2 (rt).

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