

# Fast Power Hardware-in-the-Loop Testbed for Converter-based Generation in Microgrids

A. Seibel<sup>1</sup>  
 R. Brandl<sup>1,2</sup>  
 F. Schnabel<sup>1</sup>  
 J. Steffen<sup>1</sup>  
 M. Jung<sup>1</sup>  
 P. Unruh<sup>1</sup>  
 T. Gühna<sup>1</sup>

Contact:  
 axel.seibel@iee.fraunhofer.de  
 Tel: +49 561 7294-289

Fraunhofer IEE  
 Königstor 59  
 34119 Kassel

www.iee.fraunhofer.de/en

<sup>1</sup> Fraunhofer Institute of Energy Economics and Energy System Technology

<sup>2</sup> European Distributed Energy Resource Laboratories e.V.

## Dynamic Challenges in Microgrids

Power quality issues by using spatial distributed current controlled and grid forming inverters increases due to filter and control loop resonances.

- Multiple converter interaction increases super-synchronous oscillation.
- Through power electronic generation, internal superposition signals with high harmonic proportion rises.
- Accumulation of current flicker by combination of PV and EV charging systems as well as grid forming inverters in microgrids.
- High dynamic power balancing operation due to flexible renewable power production.

Generally, coupling phase lock loops, resonances of filter circuits and improper parametrization of converter controllers causes high dynamic oscillations

## Alterable Microgrid Testbed for Dynamic Phenomena Testing

Challenging those issues, a realistic and alterable testbed is mandatory to validation new microgrid components and controls.

Fig. 1 represents the Fraunhofer SysTec IEE Microgrid testbed for:

- On-/Off-Grid / Transition mode representation of microgrids and island grids.
- Alterable grid scenario emulation with Hardware-in-the-Loop technologies.
- Multiple flexible test device connection points for interdependency testing.
- Real LV- and MV- Test Site with various consumers / prosumers:
  - Smart Homes
  - Wind Turbine
  - Diesel GenSet
  - Various Loads
  - Plug&Play Battery Systems

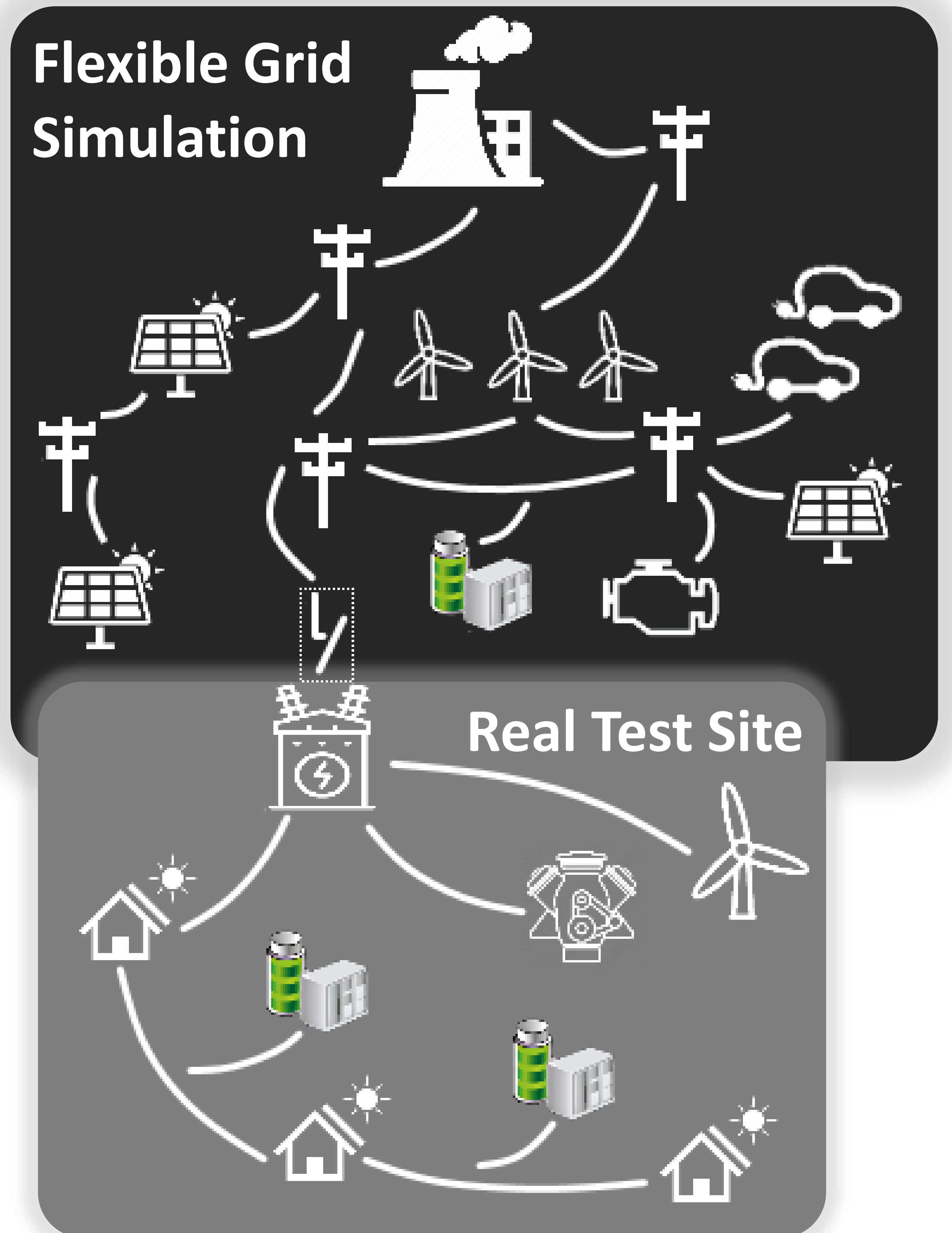


Fig. 1 – Schematic of Microgrid Testbed @ Fraunhofer SysTec IEE

## Plug&Play Grid Forming Control SelfSync+

Addressing the high alterable characteristics of microgrids, a flexible solution is required, as the Plug&Play Grid Forming unit with SelfSync+ Control developed by the Fraunhofer IEE. This systems is meant to effortlessly connect it to every possible or unknown grid situation (e.g. voltage variation in an unknown and weak grid situation, see Fig. 2).

Benefits of SelfSync+ Control:

- Spatial Distribution
- Second Source
- Easy configuration and operation
- Communication only for safety reasons

Incorporate Function & Features:

- Virtual Inertia
- Uninterruptable Power Supply
- Black Start capabilities
- Current limitation
- Dynamic oscillation damping
- Operational Management

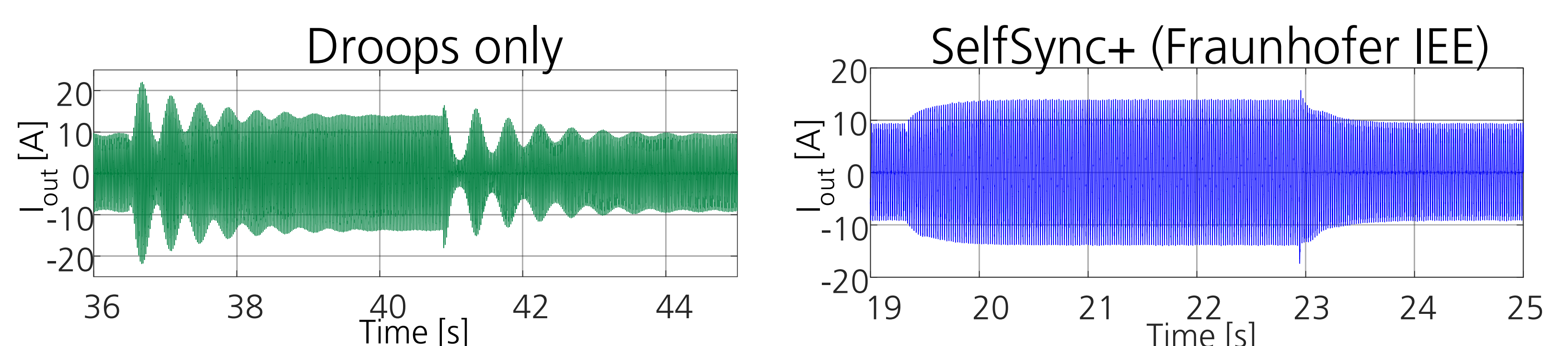


Fig. 2 – Voltage Step from 230V to 245V and back (impedance 0.345 Ω)

SPONSORED BY THE



Federal Ministry of Education and Research

## Acknowledgment

The authors acknowledge the support of the presented work by the German Ministry of Education and Research and the project executing organization VDI/VDE within the project "Plug and Play Grids: Grid forming control for spatial distributed inverters" (FKZ 03VP04170).

Only the authors are responsible for the content of this publication.