Fraunhofer Solution for Grid-Forming Inverter Developments and Innovative Ancillary Services Validation and Testing

Fraunhofer IEE

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Trends of the Energy Transition in Public Grids

- Shutdown of conventional power plants and integration of renewable energies for CO_2 reduction
- Sector coupling for efficient energy mix and storage
- Strong increase of inverters with additional requirements

Challenges for Power Electronics in Inverter-Dominated Grids

- Ensuring and extending security of supply and grid stability
- Replacing synchronous generators with appropriate inverters like grid-forming and grid-supporting inverters
- Compensation of reduced grid inertia due to the shutdown of conventional power plants
- Optimization / adaptation of grid codes
- Extension of stabilization functions, such as reactive power provision, active power balancing or reactions to grid faults
- Enhanced protection functions, such as brown / black start capability, grid protection systems, islanding detection

One Solution

Grid-forming control methods for inverters

- Grid-forming inverters offer possibilities for maintaining stable grid operation and increasing secure power supply even in grid-tied operation
- Flexibility through control parameter adaptations
- Grid forming properties even in overload situations with sufficient current limiting methods

Applications for laboratory tests

Figure 1 shows a Rapid Inverter Control Solution. The system simulates different applications like batteries, PV, Wind, charging solutions for electro mobility or power supply. The active frontend (inverter) is the connection to the physical setup for the grid-tied operation and emulates the system behavior. Even unbalanced grid controls can be realized due to the control of the neutral wire. For analyzing larger systems, interfaces to real-time computers are envisaged.
Additional unique models and libraries with grid-forming control and sufficient current limitation are implemented for efficient test setups.

One Tool for Development

RICOSO | Rapid Inverter Control Solution for grid-forming inverters

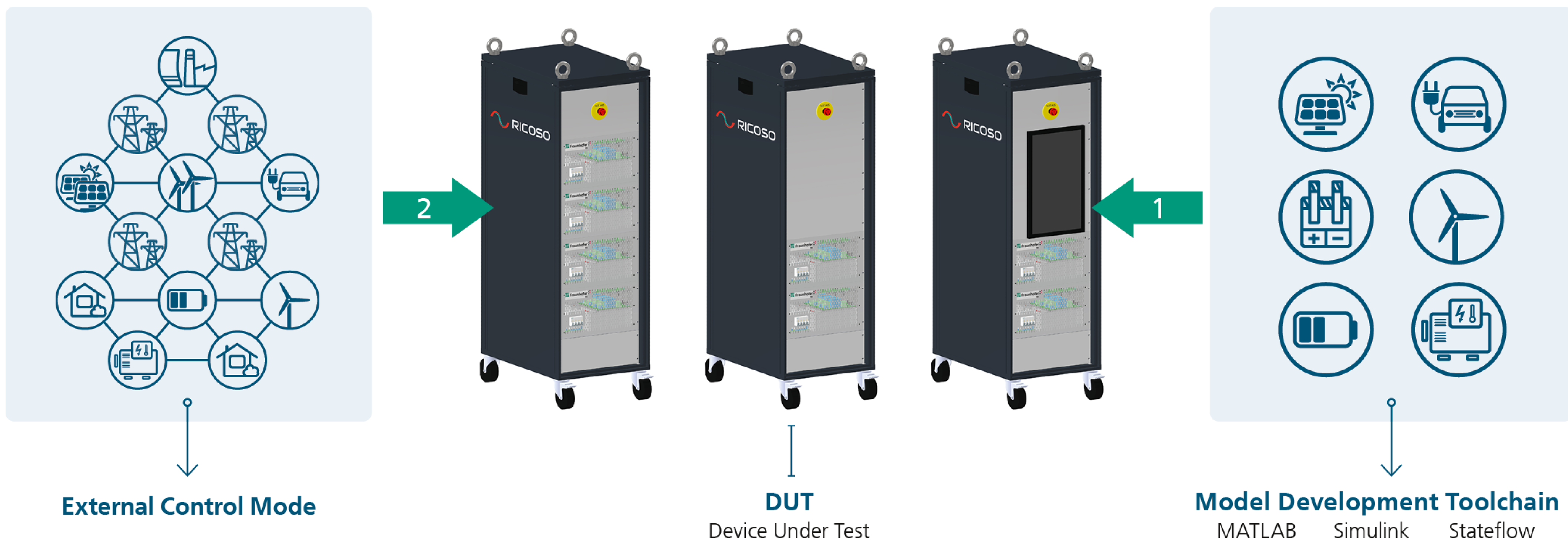

Figure1: Practical development and research of control algorithms in laboratories Path 1 direct programming; Path 2 external mode for larger system emulation

Drop Control and Parallel Operation for Grid-Forming Inverters

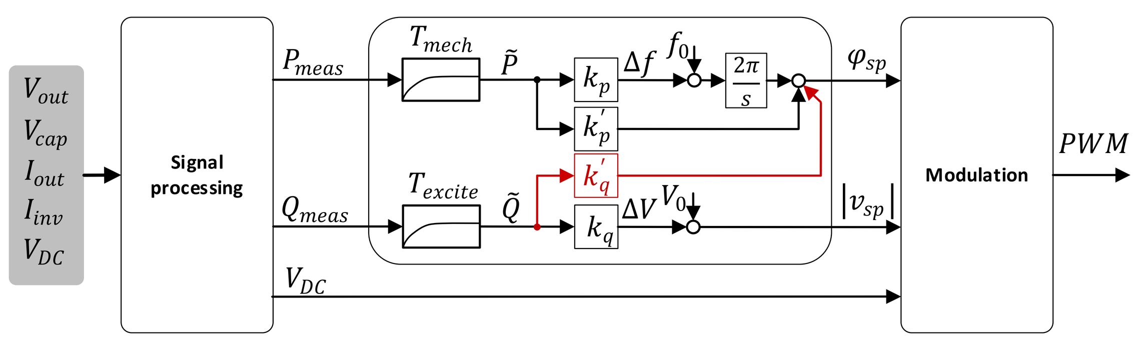

Figure 2: P. Unruh, T.Gühna, „Distributed grid-forming inverters in power grids", in 7. Solar Integration Workshop

- Additional phase feedforward for predominantly resistive grids in spatial distribution
- Grid-Forming Inverters (GFM) with "small" output filter impedance
- Potential to decrease the need for additional decoupling inductors
- Higher cost efficiency of the hardware design
- Improved dynamic behavior

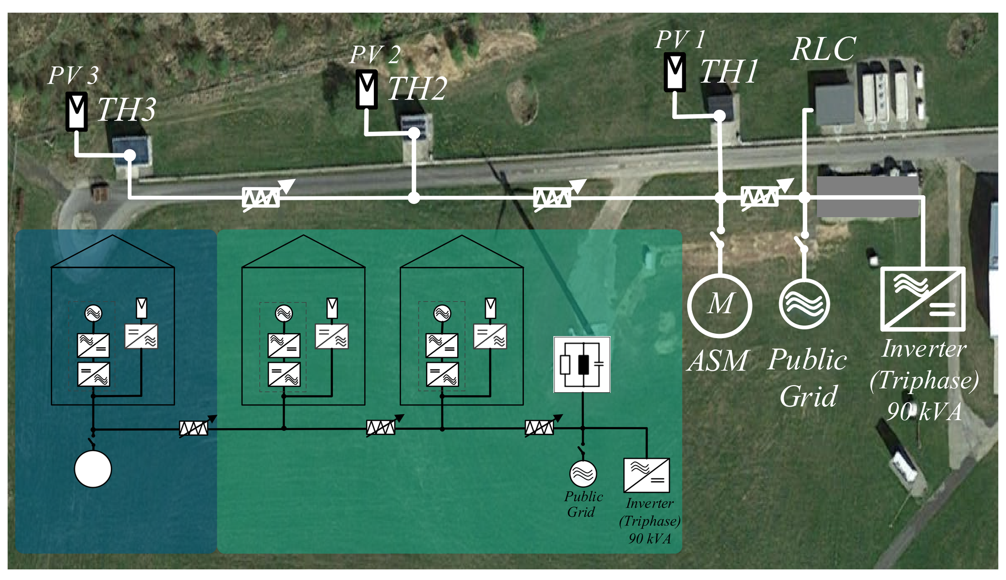

Figure 3: Test setup with three distributed GFM (2 x 43 kVA RICOSO, 1 x 90 kVA)

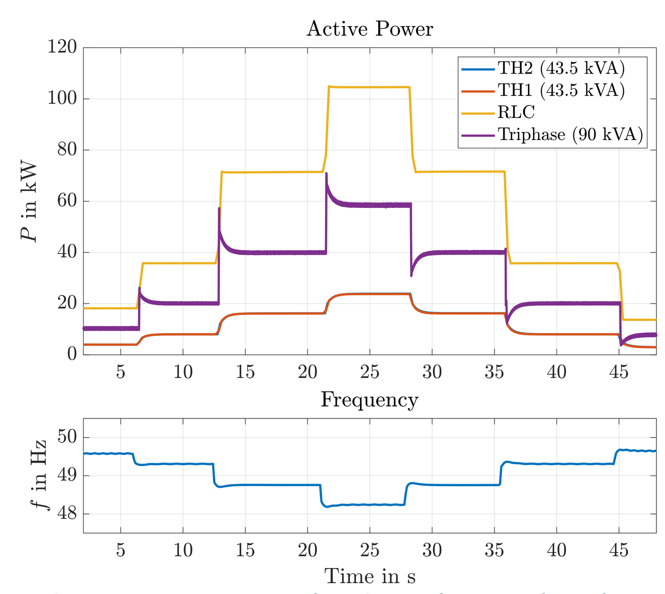

Figure 4: Power sharing due to load variation of distributed GFM and frequency response with drops

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DE10140783 (including US, EP, JP)	DE102014223441	DE102016203123	DE102019214682	DE102020200673	DE102021206502
Droop control for grid-forming inverters with phase feedforward for stable parallel operation (SelfSync)	Fault detection for electrical grids enables fast response of power converters to network faults. Contribution to grid support and protection of power converters	Extension of droop control for grid-forming inverters, especially for weak grids and low-voltage grids (SelfSync+)	Power inverters as a protection element for electrical grids. Fault detection and emission of a signal for protection devices.	Current limiting for power inverters with virtual impedances	Current limitation for grid-forming power inverters with prioritization of reactive or active power

RICOSO