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Power Hardware-in-the-Loop Studies for Transmission Network Stability Behaviors

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Prospects of Power Hardware-in-the-Loop Systems

Power Hardware-in-the-Loop (PHIL) technologies increases in field of network component (Hardware-under-Test HUT) testing.

Compared with pure simulation based methods, this technology enables more possibilities in testing and studying network stability behaviors.

Two possibilities will be depicted:

- Global network stability studies including HUT
- HUT testing for more realistic network events

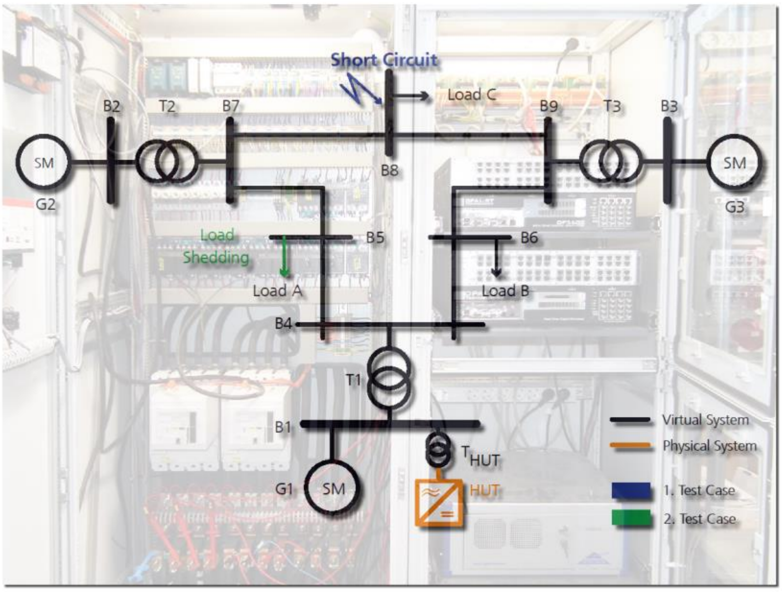

Fig. 1 IEEE 9-Bus Model in a PHIL System

Exemplary Setup for Global and Holistic Network and Component Investigations

The scientific respected network model of the IEEE 9-Bus system was simulated in real-time. Via a physical system containing power amplifiers and measurement probes an inverter was connected to the numerical simulation (Fig. 1).

The HUT represents the dynamics of a wind park equivalent.

Case 1 – Active Power Recovery Rate after Fault-Ride-Through

A short circuit was generated on Bus B8 in the simulation. Generator G1 was replaced by the HUT on Bus B1.

A fast and a slow power rate of the HUT was tested and compared to an active Generator G1.

Case 2 – Electronic Inertia Control for Wind Parks

A Load shedding was generated on Load A of 25%.

An inertia controller with df/dt dependency was implemented on the HUT and compared to a non-active case. The HUT replaced 30% power of G1.

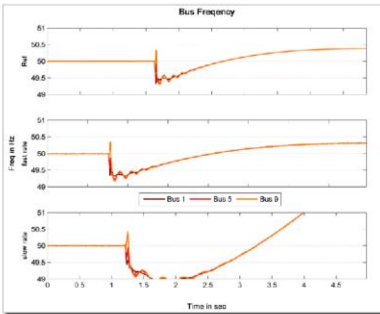

Fig. 2 Case 1 – A slower recovery rate leads the system to instable cases (lower diagram)

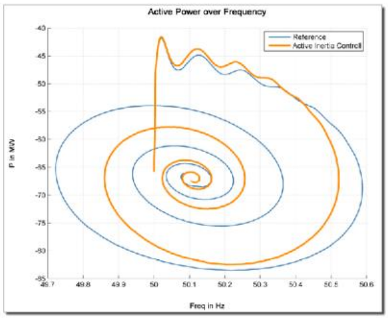

Fig. 3 Case 2 – The inertia controller damps the frequency magnitude and reaches faster its steady state (orange)

Faster Power Rate is Favorable

- A system with active G1 has the highest stability
- A faster rate provides better support (see Fig. 2)

Active Support of Frequency Imbalances with Inertia Control

- The implemented controller damped the magnitude and oscillation of the frequency imbalance (see Fig. 3)

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