Flywheel Energy Storage System based Microgrid Controller Design and PHIL Testing

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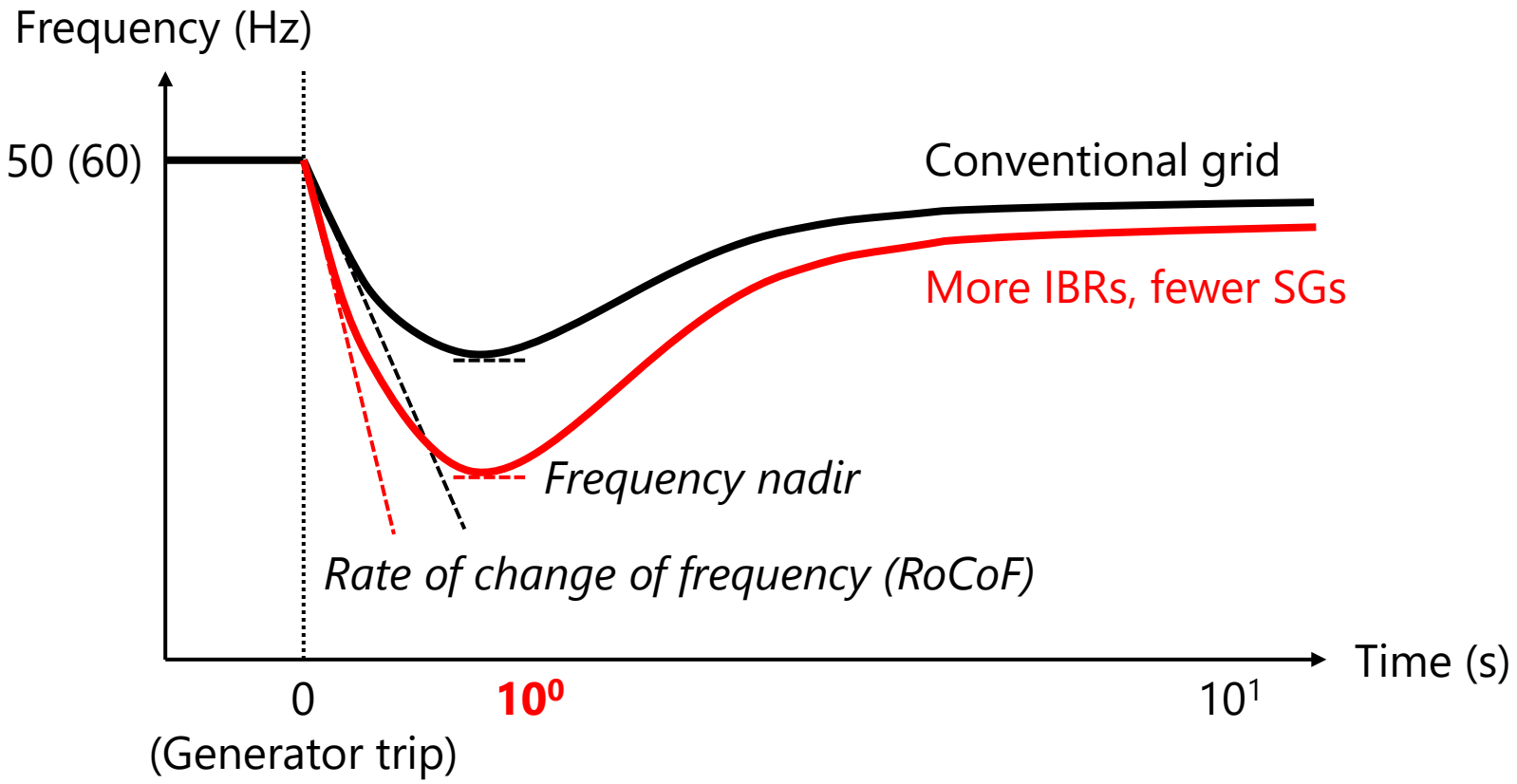
FESS is an Alternative to Provide FFR Capability in IBR Dominant Grid

- Fast frequency response (FFR) capability of synchronous generator (SG) needs to be alternated in power system with high penetration of inverter based-resources (IBRs)
- Flywheel Energy Storage System (FESS) is an option for providing FFR



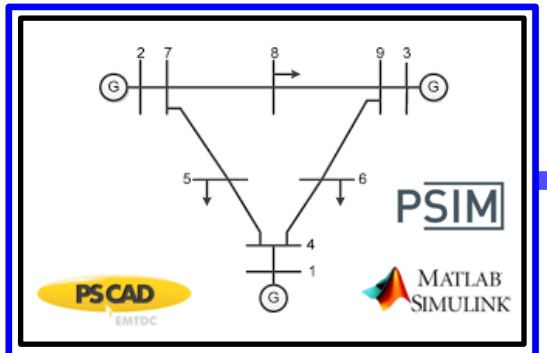
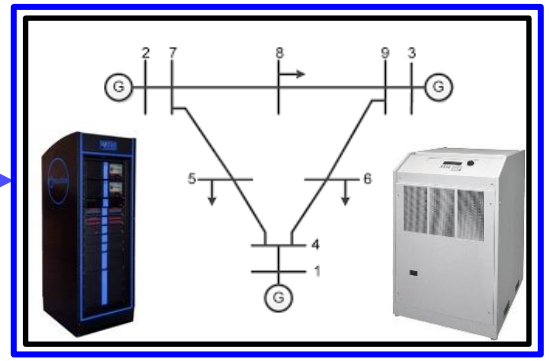
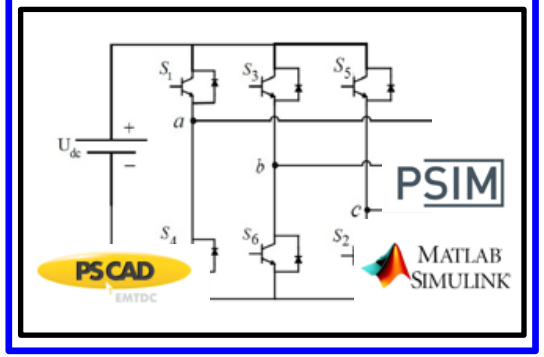
Hybrid ESS of flywheel and battery w/ EMS

- Jointly developed by Nippon Koei and STRONETIC
  - Flywheel: autonomous control
  - Battery: external control (every 100 ms)

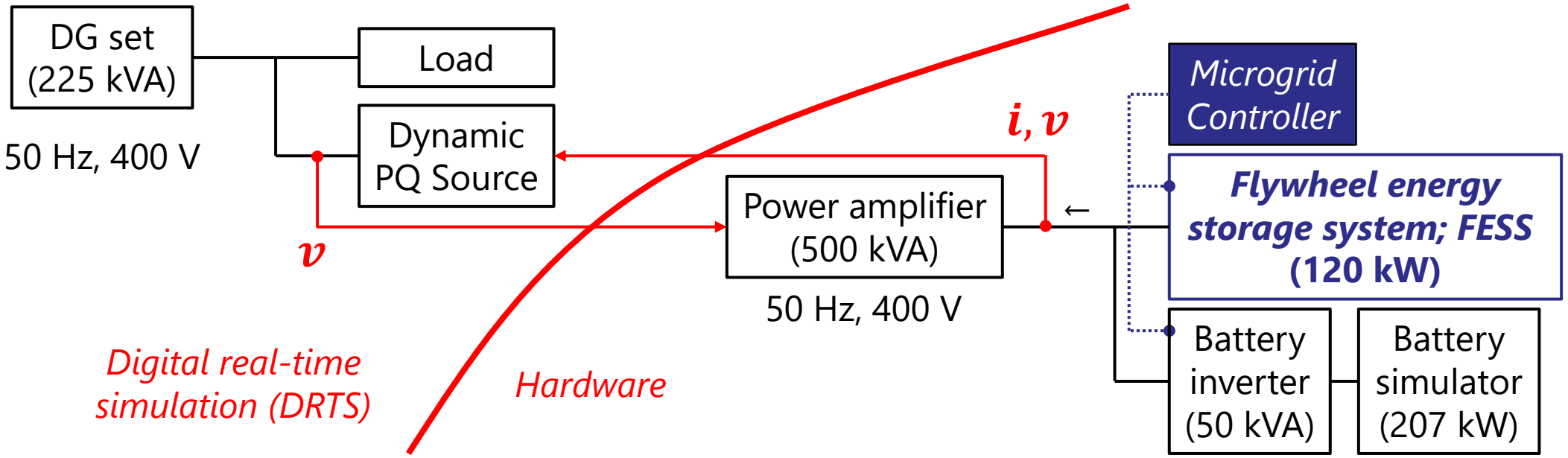
- Specification of FESS
  - Rated capacity: 120 kW / 7.2 kWh
  - Rotating speed: max. 45,000 rpm
  - Full-charge/discharge: 260 s
  - Efficiency: 92%

- Advantage to chemical battery
  - Transportable: standard shipping
  - Recyclable: no hazardous materials
  - Long life: no degradation

PHIL Simulation is Suitable for Pre-Testing

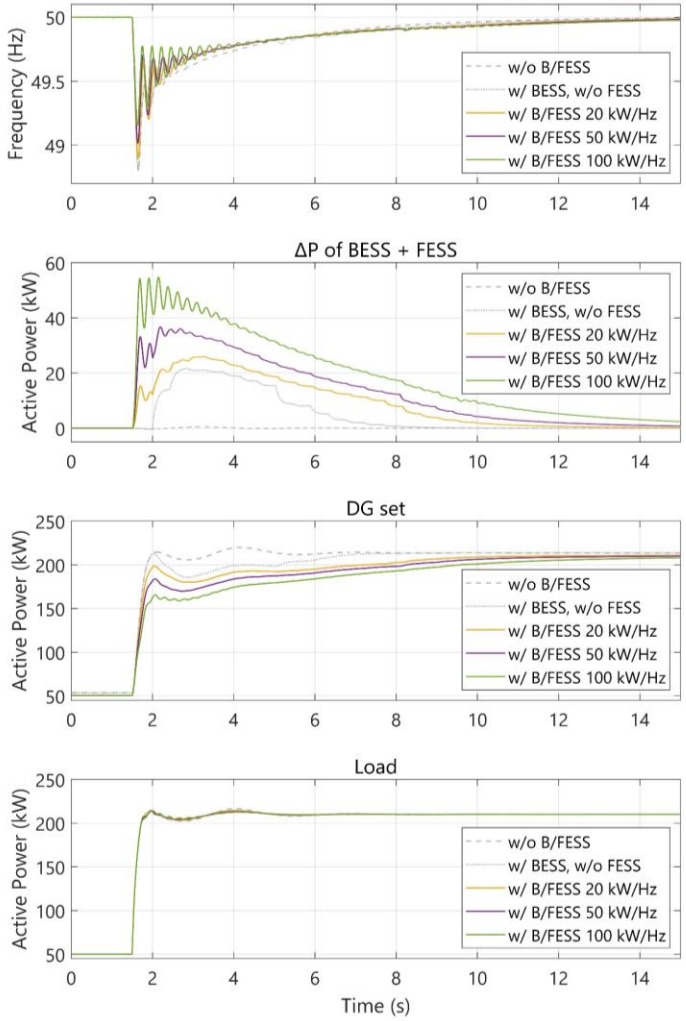
	Full simulation	Demonstration	**Hardware-in-the-loop (HIL) simulation**
Grid			
DER			
Flexibility	**High**	Low	**High**
Fidelity	Low	**High**	**High**

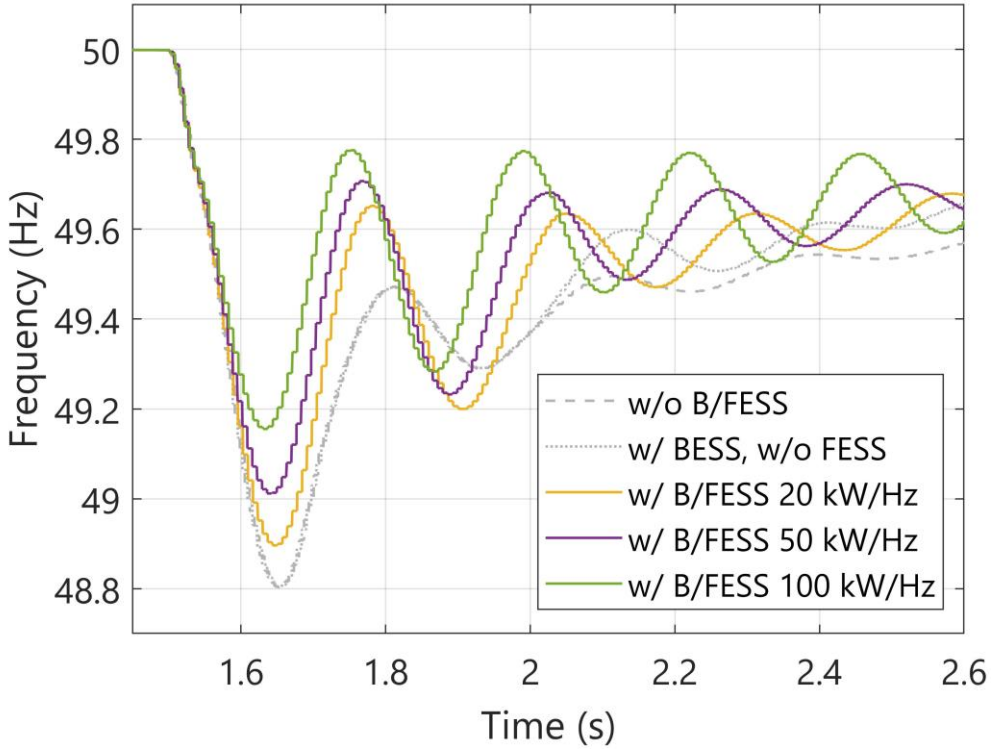
PHIL Environment for Testing FESS based Microgrid



PHIL Test Result (Load Increase Event: 50 to 210 kW)

- Verified contribution of FESS to earlier frequency stabilization
- Verified frequency droop control characteristics of FESS





Summary

- FESS is an alternative to SGs that provide FFR capability in IBR dominant grid

- Developed hybrid (flywheel and battery) system with EMS
  - Flywheel: autonomous frequency control, external parameter setting from EMS
  - Battery: external control from EMS

- Conducted PHIL testing of FESS based microgrid
  - Introduction of FESS contributed to earlier frequency stabilization
  - Verified frequency droop control characteristic of FESS

- Future work
  - Application to bulk power systems

Appendix

FESS is an Alternative to Provide FFR Capability in IBR Dominant Grid

- Fast frequency response (FFR) capability of synchronous generator needs to be alternated in power system with high penetration of inverter based-resources (IBRs)
- Flywheel Energy Storage System (FESS) is an option for providing FFR