Integrated Power Hardware-in-the-Loop and Lab Testing for Microgrid Controller

Hiroshi Kikusato, Taha Selim Ustun, Masaichi Suzuki,
Shuichi Sugahara, Jun Hashimoto, Kenji Otani
Fukushima Renewable Energy Institute, AIST (FREA)

Kenji Shirakawa, Rina Yabuki, Ken Watanabe, Tatsuaki Shimizu
Nippon Koei Co. Ltd.

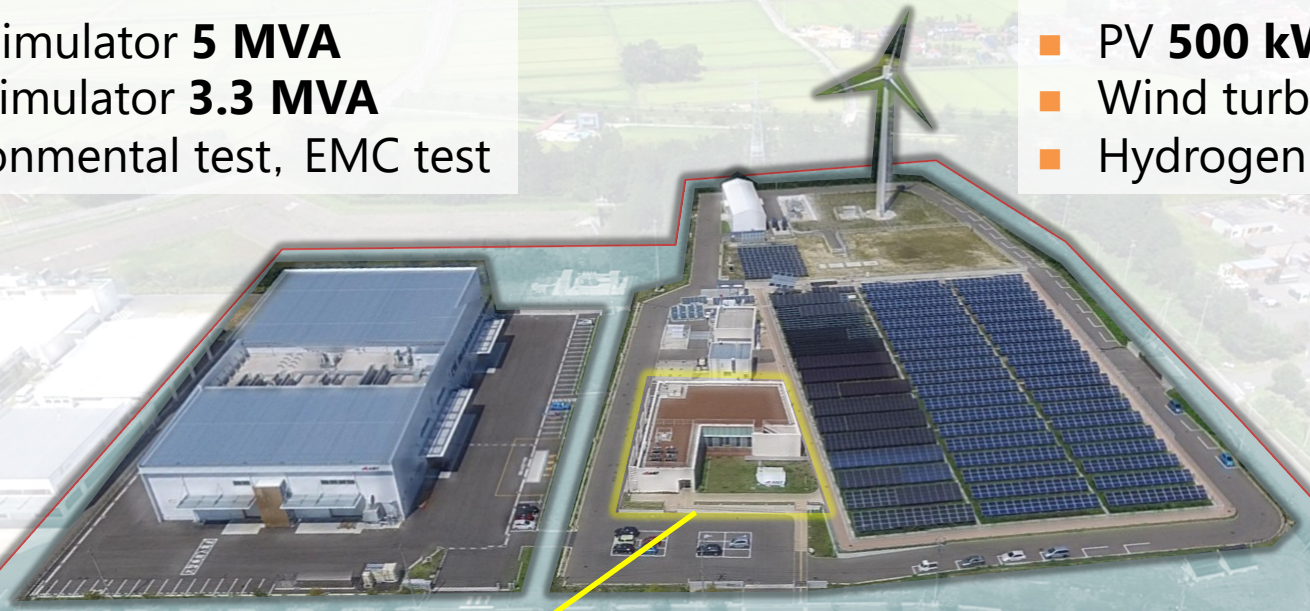
Fukushima Renewable Energy Institute, AIST (FREA)

FREA-G

- Grid simulator **5 MVA**
- DER simulator **3.3 MVA**
- Environmental test, EMC test

Demonstration Field

- PV **500 kW**
- Wind turbine **300 kW**
- Hydrogen plants



Test Lab

- Grid simulator **500 kVA**
- PV simulator **600 kVA**
- Battery simulator **200 kVA**
- PV, battery inverters, load bank
- Connection to demonstration field

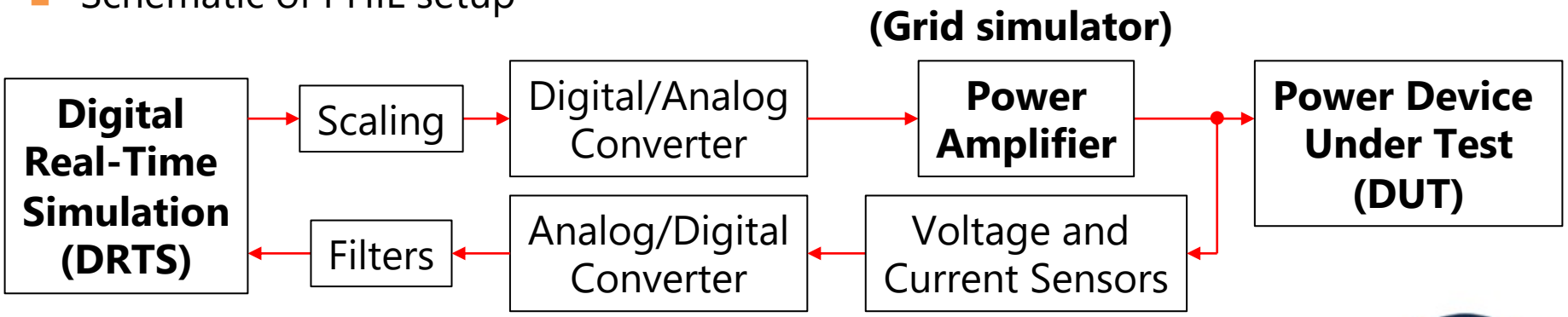
Source: Google Maps

Development and Testing of DER

- Need to be tested in advance for reducing risks of on-site deployment

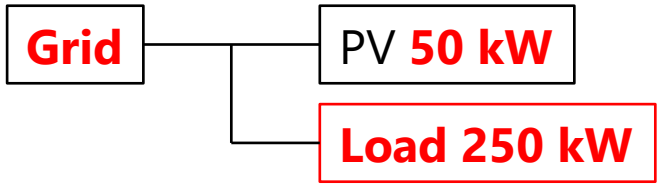
Testing environment	Flexibility	Fidelity
Simulation	High	Low
Lab Test	Low	High
Power Hardware-In-the-Loop (PHIL)	High	High

- Schematic of PHIL setup

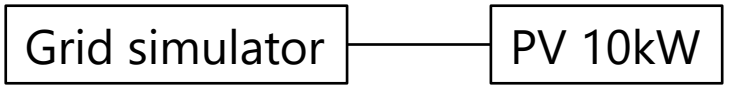


Expansion of testing capability by PHIL

- Desired setup

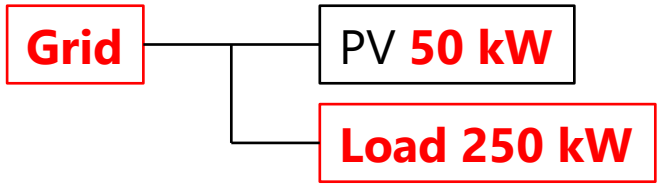


- Existing devices in the lab

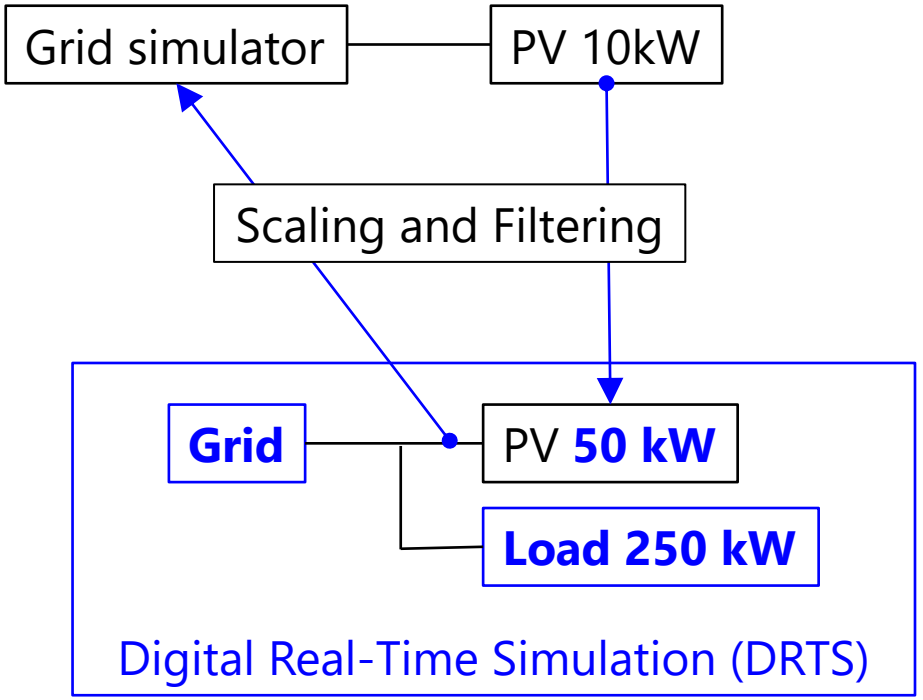


Expansion of testing capability by PHIL

- Desired setup

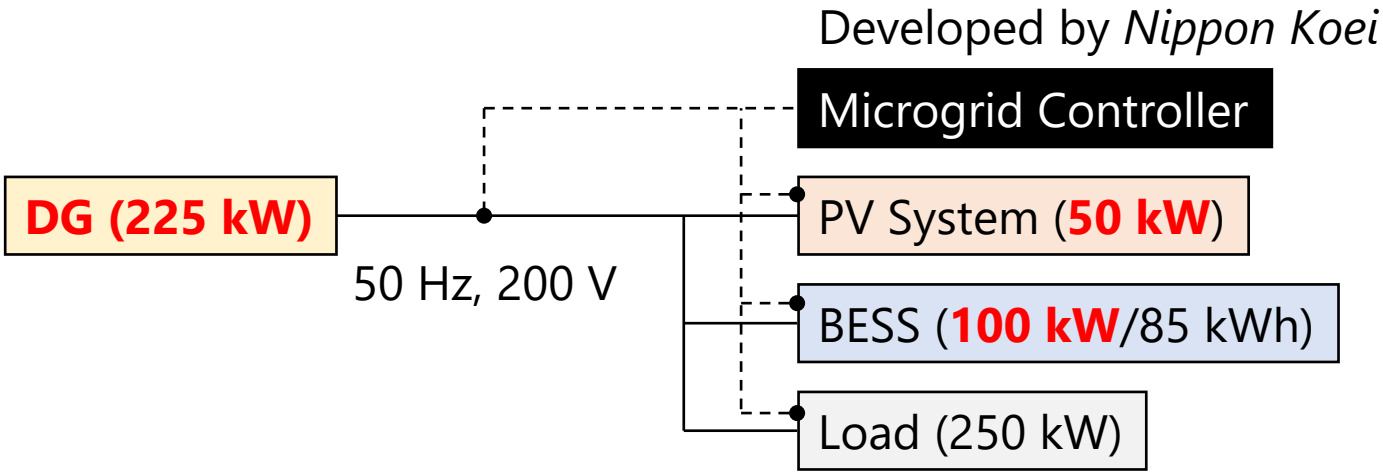


- Existing devices in the lab



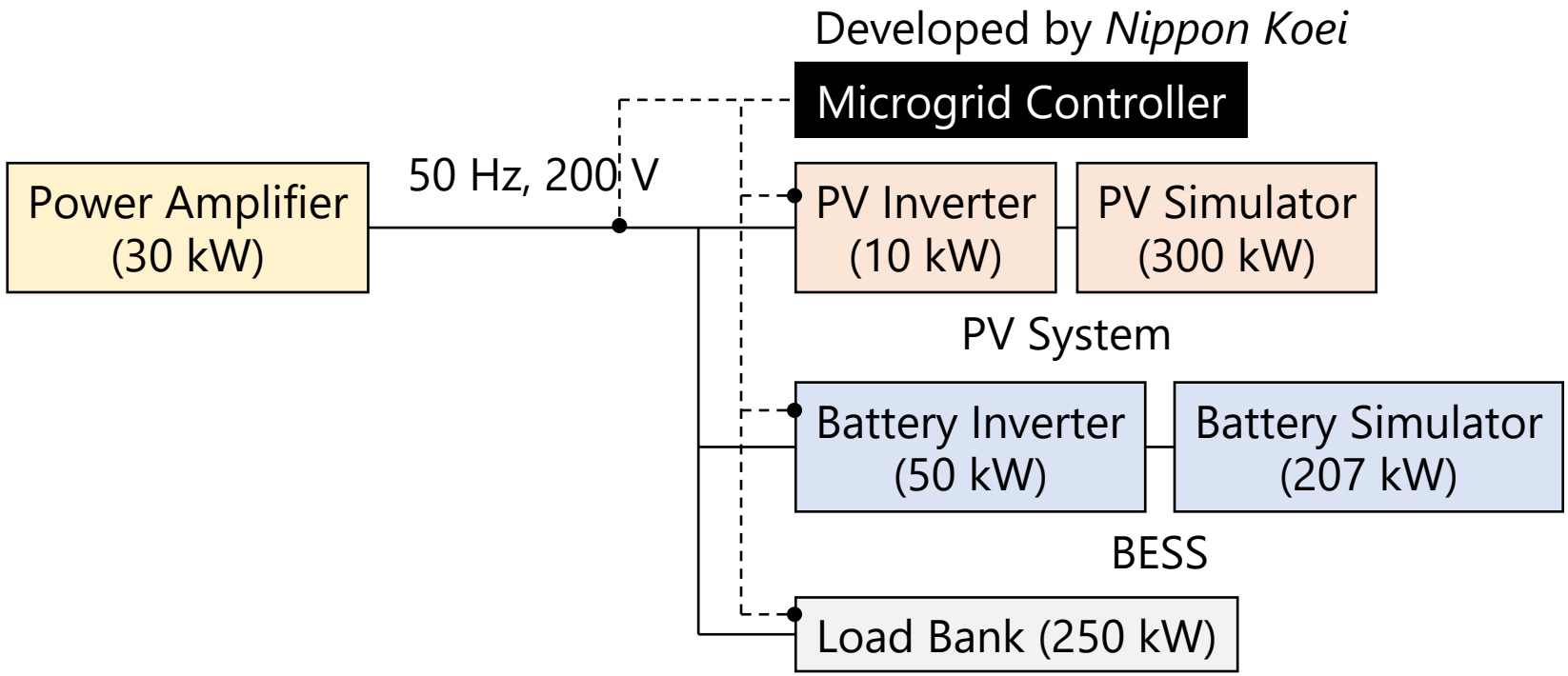
- **Purpose of this research**
  - Expand testing capability of FREA's lab by PHIL
  - Test microgrid controller

Microgrid Configuration

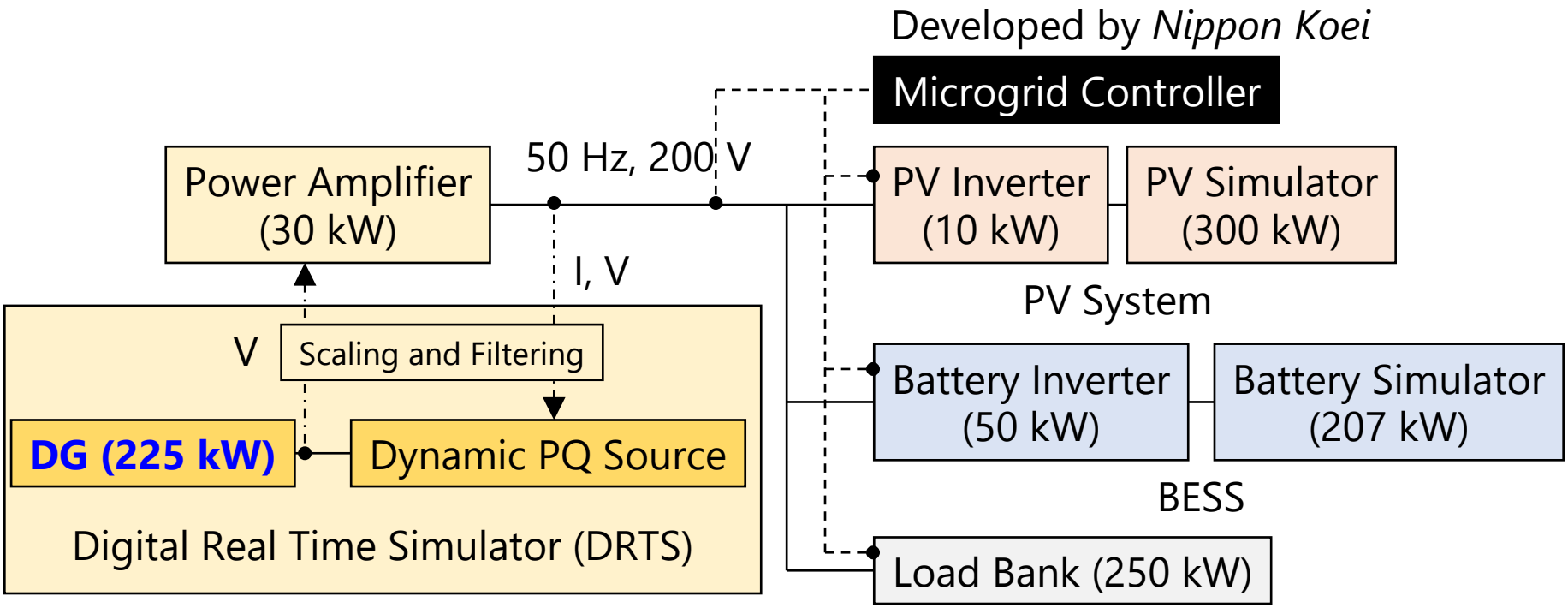


- Install PV, BESS and microgrid controller to the off-grid system
- Test functions of microgrid controller
  - Supply-demand control
  - Frequency control
- **FREA's test lab does not have DG and enough capacities**

Integration of PHIL and Lab Tests Capabilities



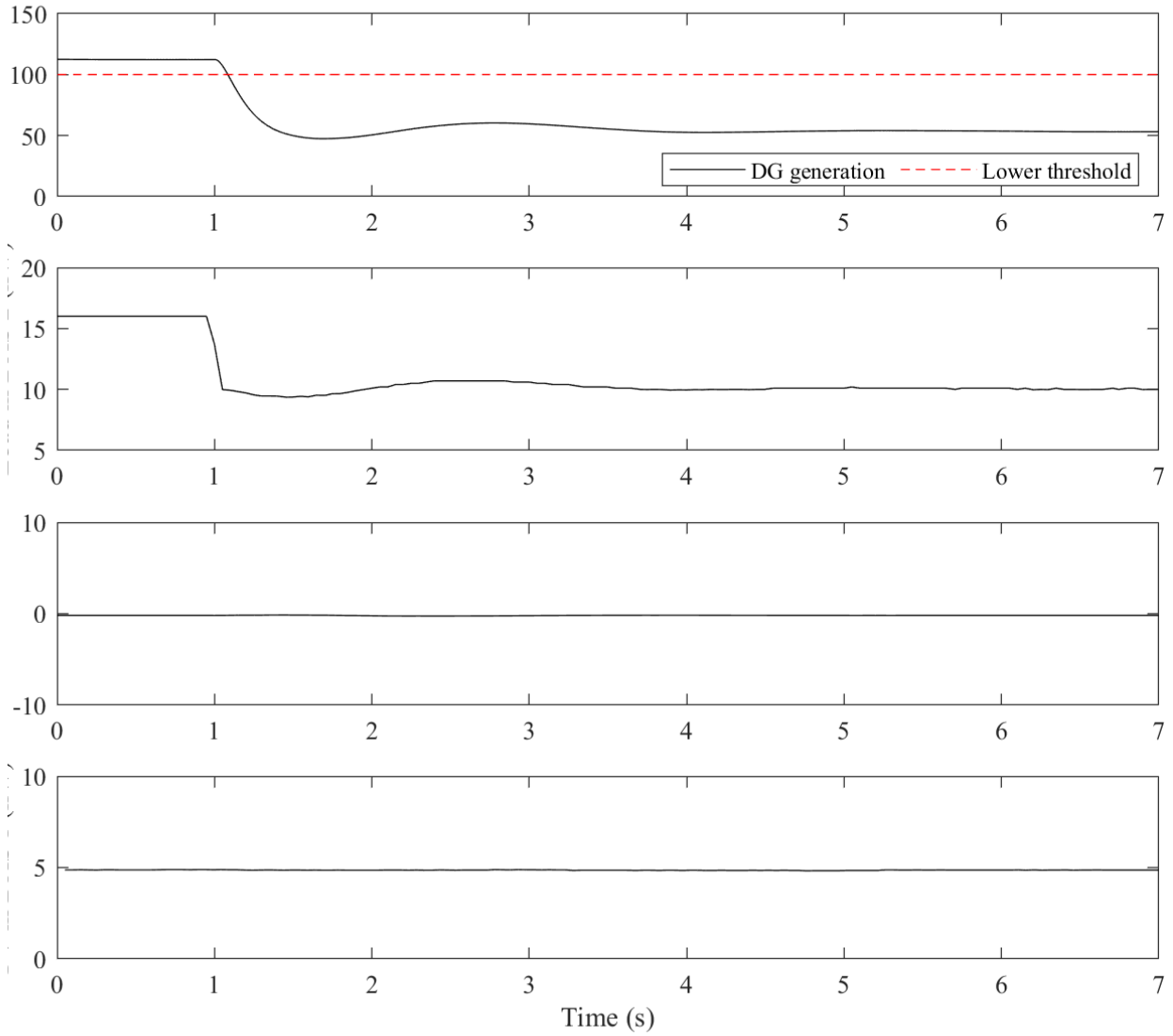
Integration of PHIL and Lab Tests Capabilities



	Actual Rating	Capacity	Scaled Rating
DG	225 kW	30 kW	22.5 kW
PV System	50 kW	10 kW	5 kW
BESS	100 kW	50 kW	10 kW
Load	250 kW	250 kW	25 kW

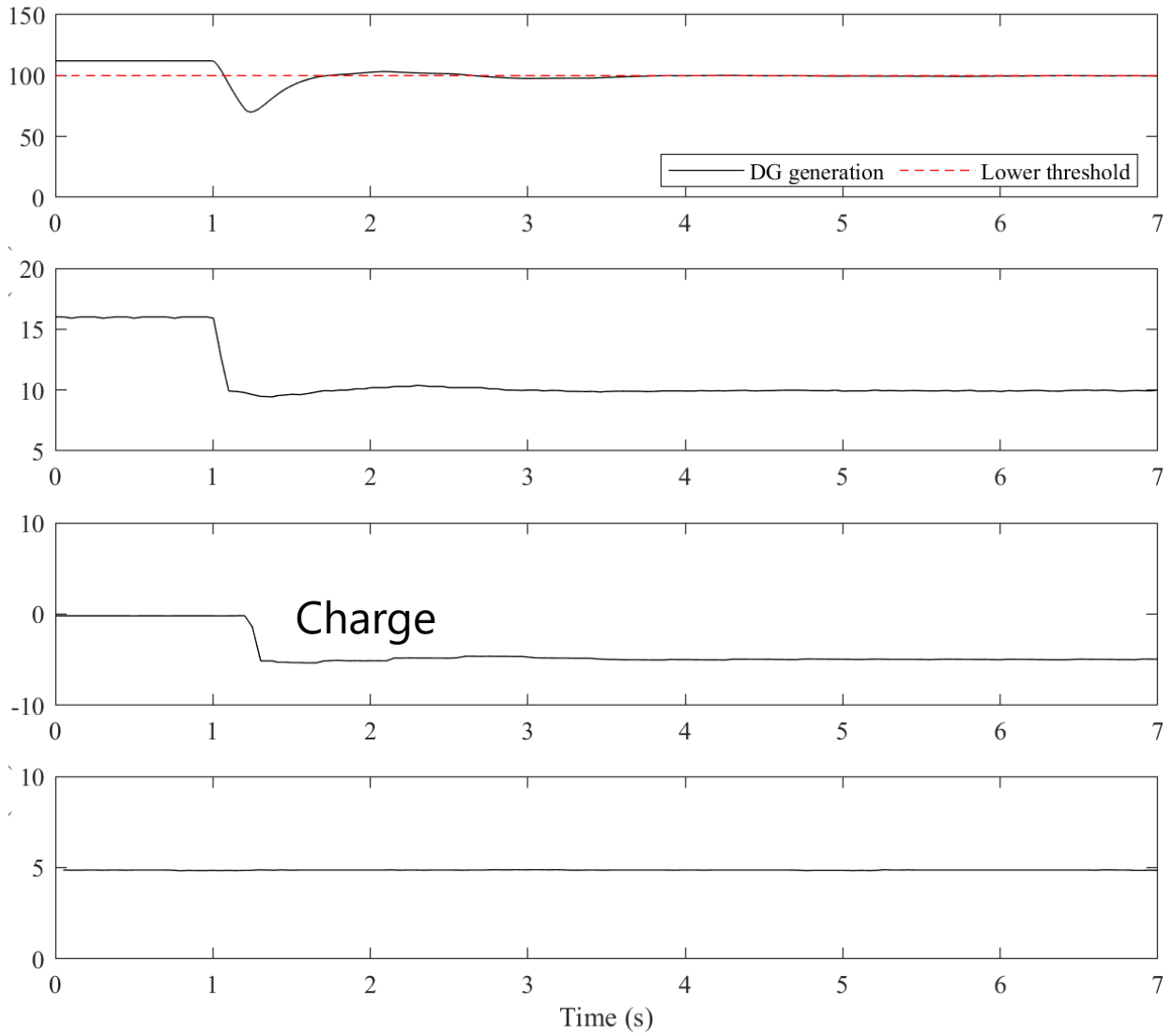
Test Result of Supply-Demand Control (w/o Any Function)

DRTS



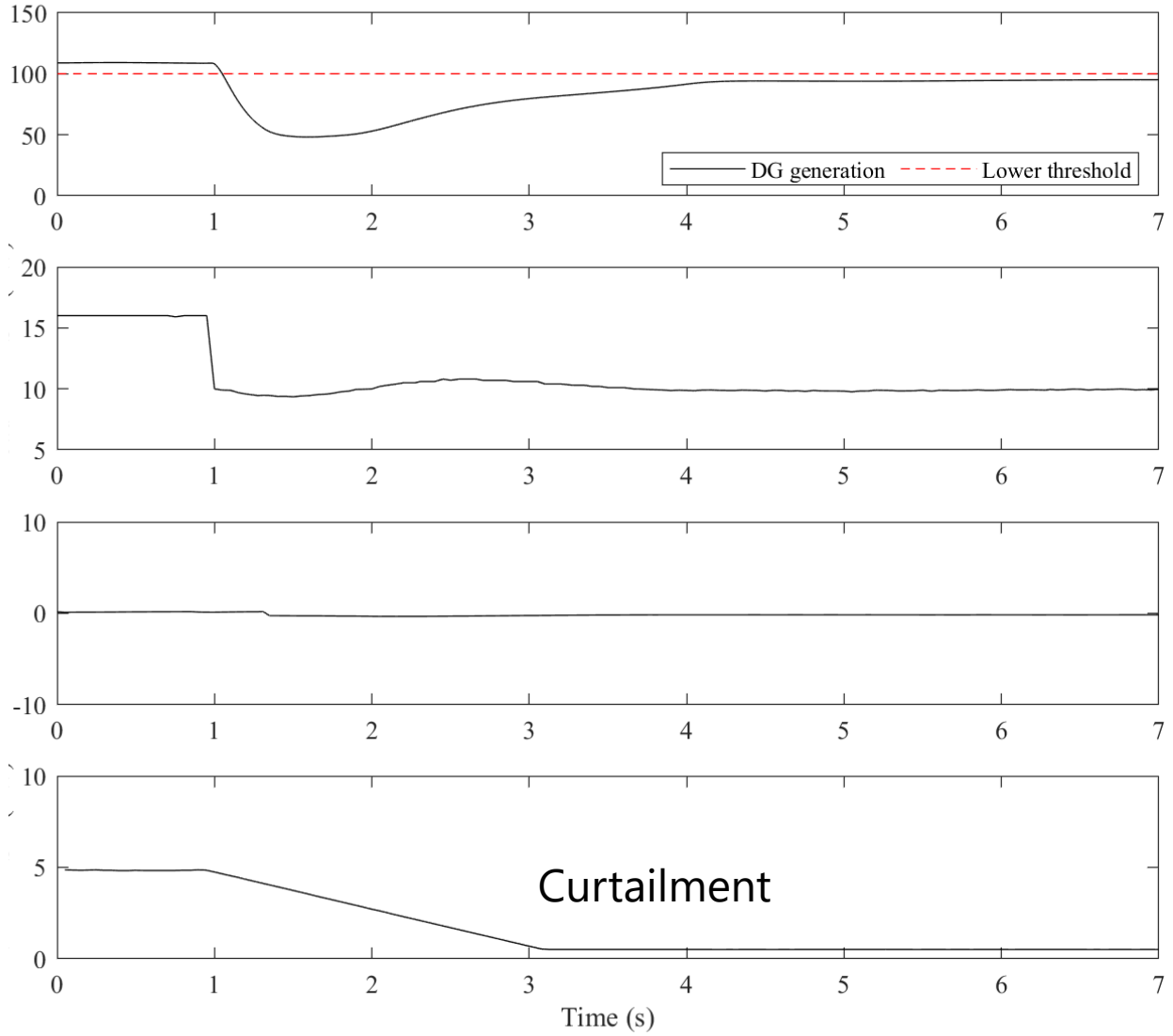
Test Result of Supply-Demand Control (w/ Function of Battery Charge)

DRTS



Test Result of Supply-Demand Control (w/ Function of PV Curtailment)

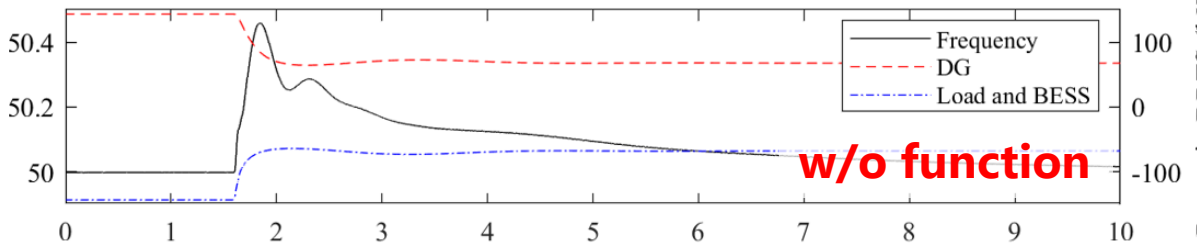
DRTS



Test Result of Frequency Control

DRTS

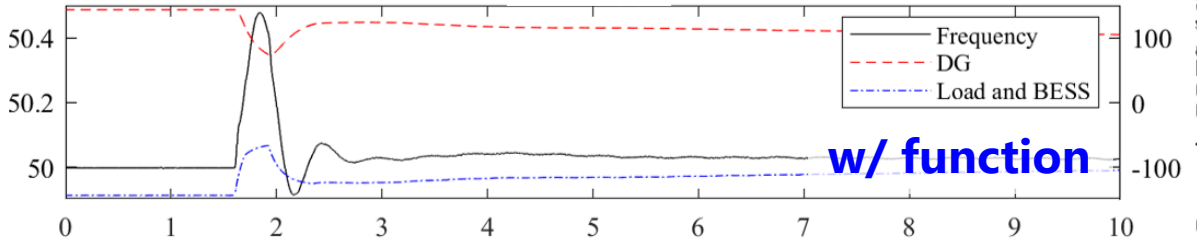
Freq. (Hz)



DG (kW)

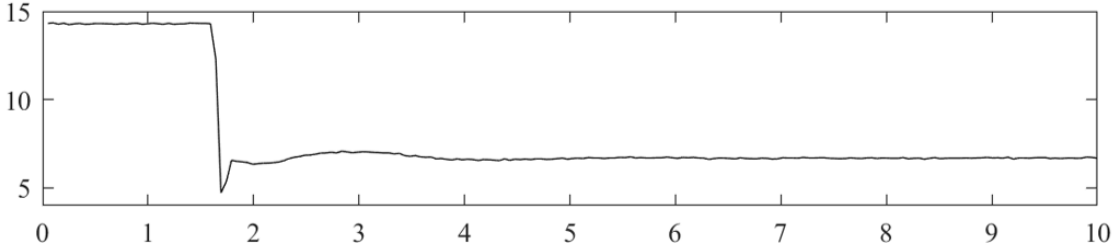
DRTS

Freq. (Hz)

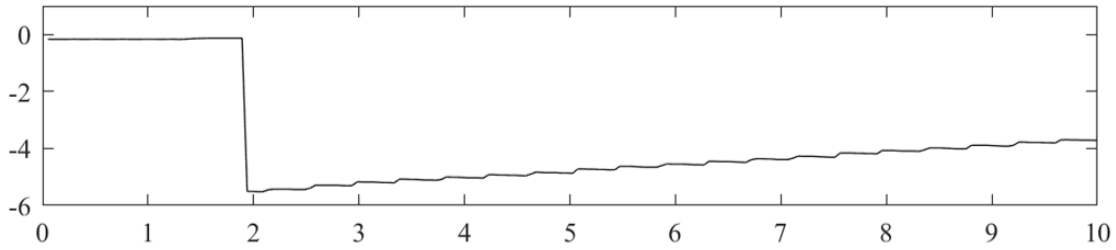


DG (kW)

Load (kW)



BESS (kW)



Summary

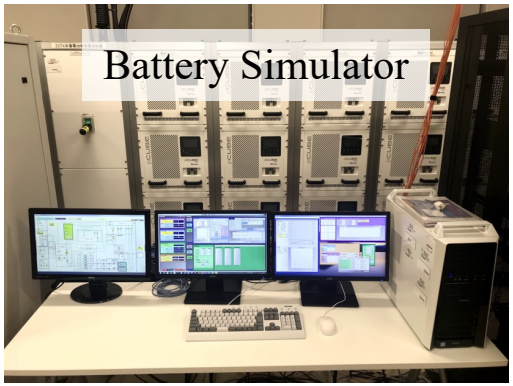
- DERs need to be tested before on-site deployment
- Expanded testing capability of FREA's lab by PHIL
- Verified the capability to run microgrid controller function tests which have a time resolution of 0.1 seconds

- Updating microgrid control function and test capability

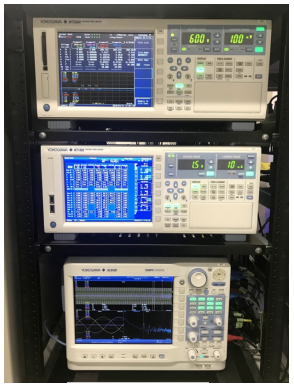
Appendix

nverter

Microgrid Controller

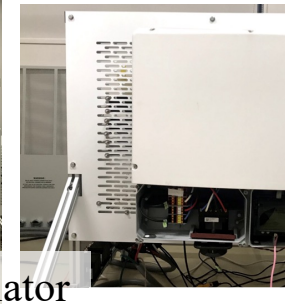


Control Desk



DASs

DRTS



PV Inverte