

Power Hardware-In-the-Loop Testing of 500kW PV Inverter

Hiroshi KIKUSATO

Fukushima Renewable Energy Institute, AIST (FREA)

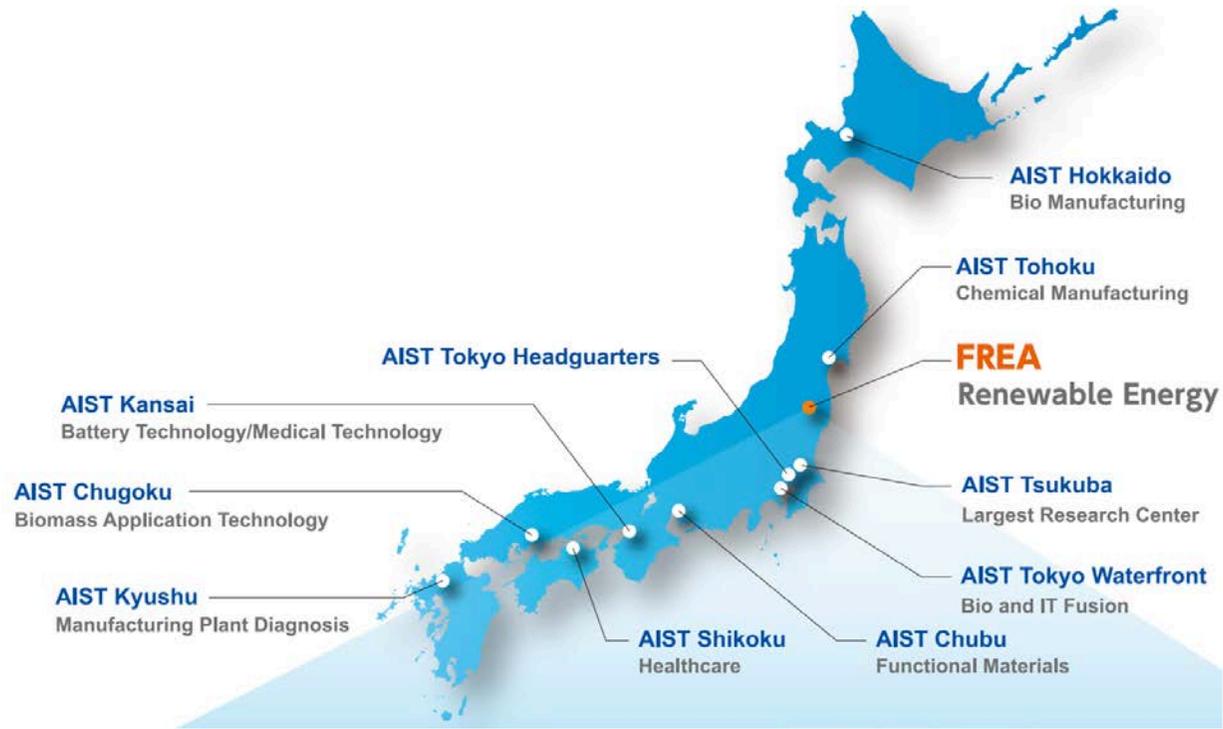
National Institute of Advanced Industrial Science and Technology (AIST)

hiroshi-kikusato@aist.go.jp

5th International Workshop on
Grid Simulator Testing of Wind Turbine Drivetrains
@FSU, 13-14 November, 2018

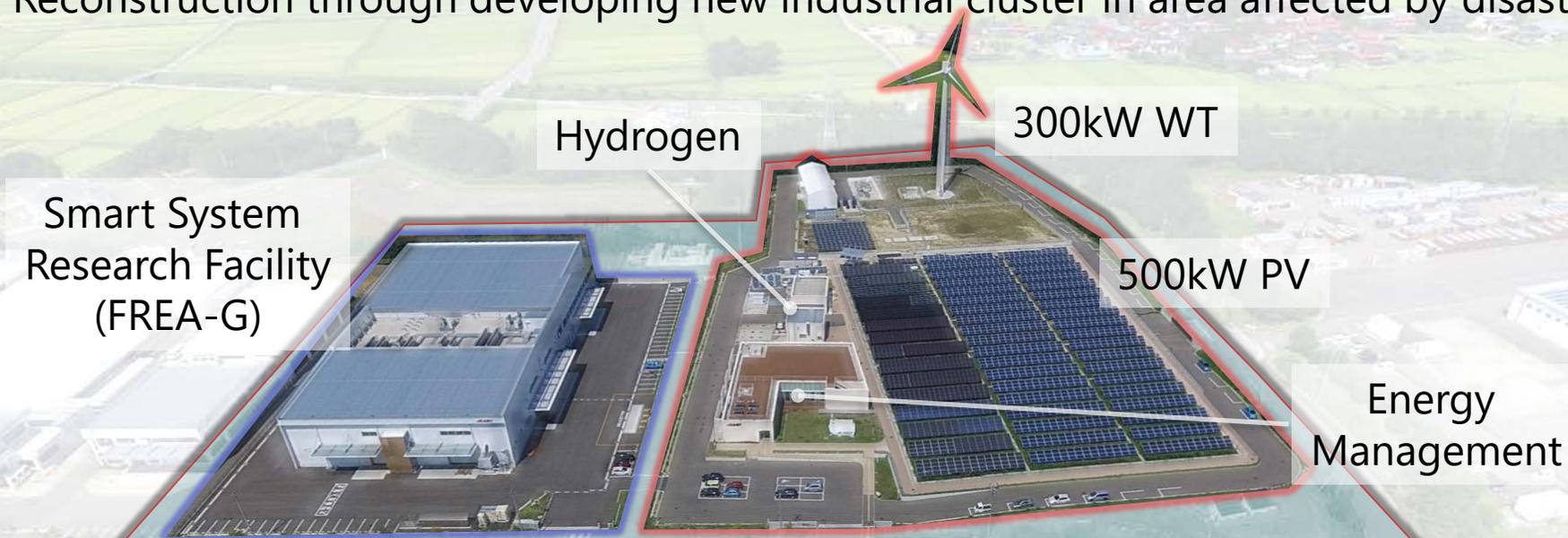
About AIST National Institute of Advanced Industrial Science and Technology

- One of the largest public research organizations in Japan,
 - Established in 2001 via the merger of 16 institutes under the METI
 - Has over 2000 researchers in 7 research departments 
 - Ranked 5th on the World's Most Innovative Research Institutions in 2017



About **FREIA** Fukushima Renewable Energy Institute, AIST

- Established in Koriyama, Fukushima in 2014 for promoting
 - R&D of renewable energy internationally
 - Reconstruction through developing new industrial cluster in area affected by disaster



- Has over 200 researchers in 7 research teams



Energy Network



Hydrogen Energy Carrier



H₂ and Heat Utilization



Wind Power



Photovoltaic Power



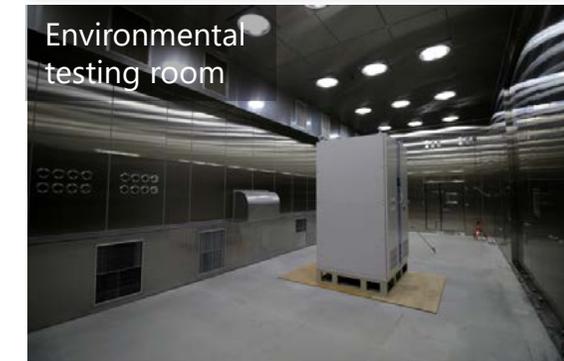
Geothermal Energy



Shallow Geothermal

Smart System Research Facility called "FREAA-G"

- Established in 2016 for testing grid connected inverters
- Testing capability
 - Grid simulator: AC 5MVA (1.67MVA × 3 units)
 - DER simulator: DC 3.3MVA, 2000V
 - Grid connection testing room (L, M, S)
 - Environmental testing room: -40 to +85°C, 30 to 90%RH
 - EMC testing room: 34m×34m×7.8m, largest in Japan



R&D Platform for Grid Connected Devices

- Smart Inverter (PV/battery inverter)
 - Grid support function: fixed PF, Volt-Var/Watt, Frequency-Watt, etc.
 - Ride through function: Low/High Voltage/Frequency ride through
 - Communication function: external update of parameters

Design

- Requirement analysis
- Software platform

Development

@Manufacturer



<https://www.renewable.pr.aist.go.jp/ent/>

Test

- Device test
- PHIL test
- Hardware platform



<https://www.rtds.com/>

Standardization

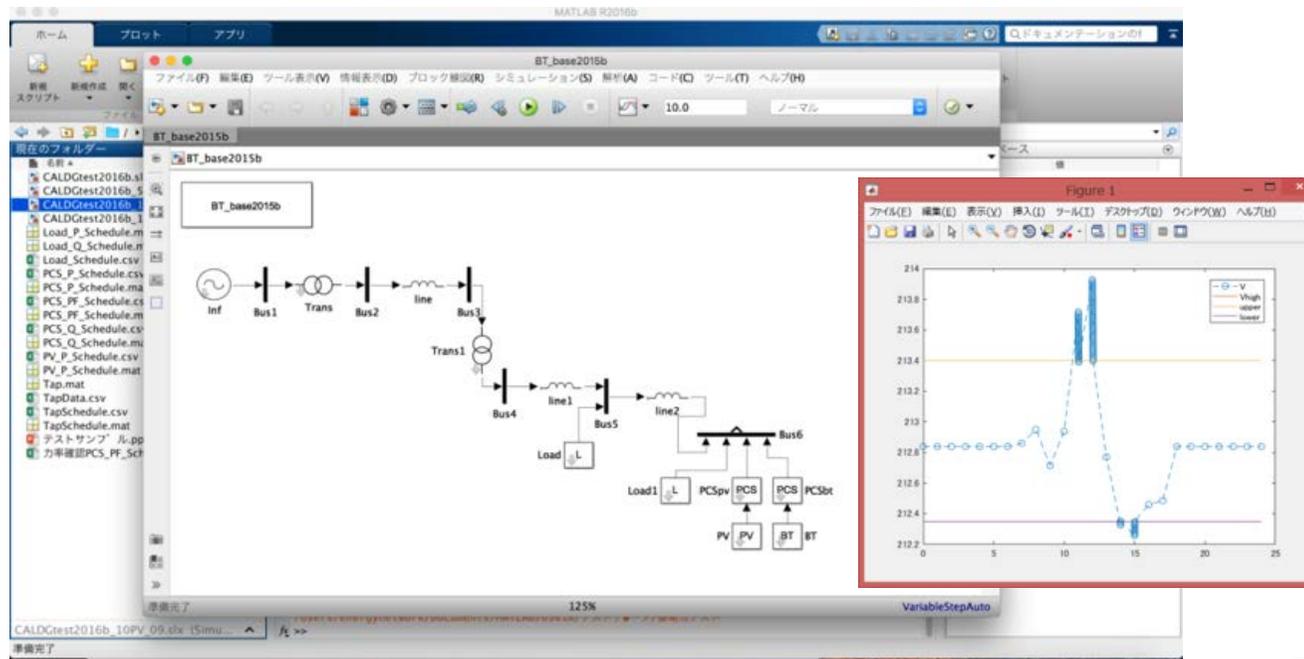
- Function requirement
- Testing scheme



Johnson et al., WCPEC 2018

SoRA-Grid **S**olar **R**esource **A**pplication for **G**rid Power Flow Analysis Tool

- Electric power system analysis software based on MATLAB/Simulink
- Available for requirement analysis of developing devices
- Characteristics
 - Can build grid configuration on GUI
 - Have various power system devices including inverter model based on IEC61850
 - Perform RMS value power flow calculation in small and large time steps

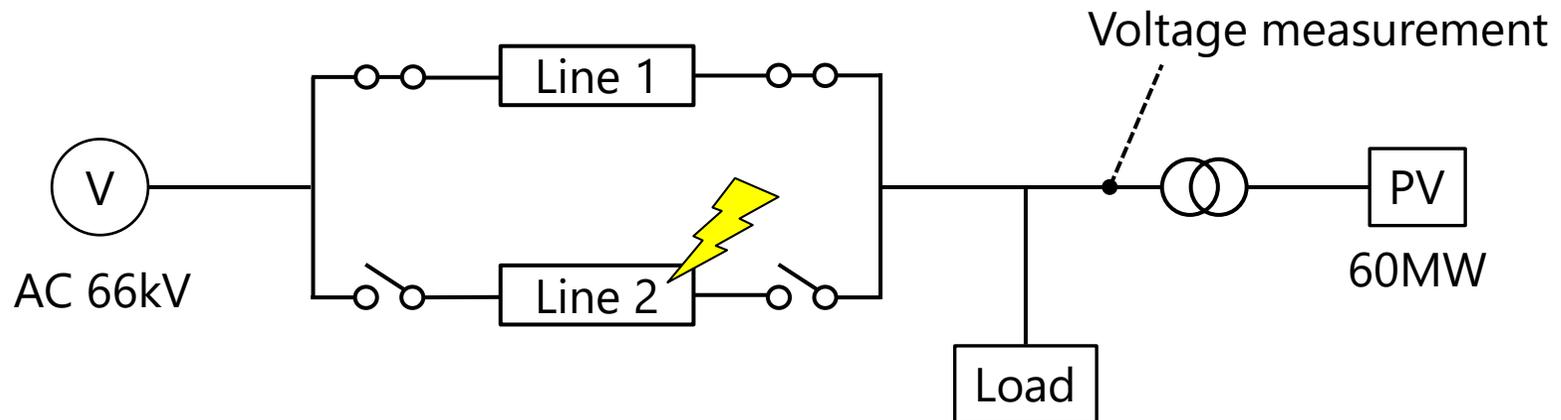


SoRA | Solar Resource Application platform
Renewable Energy & DER integration

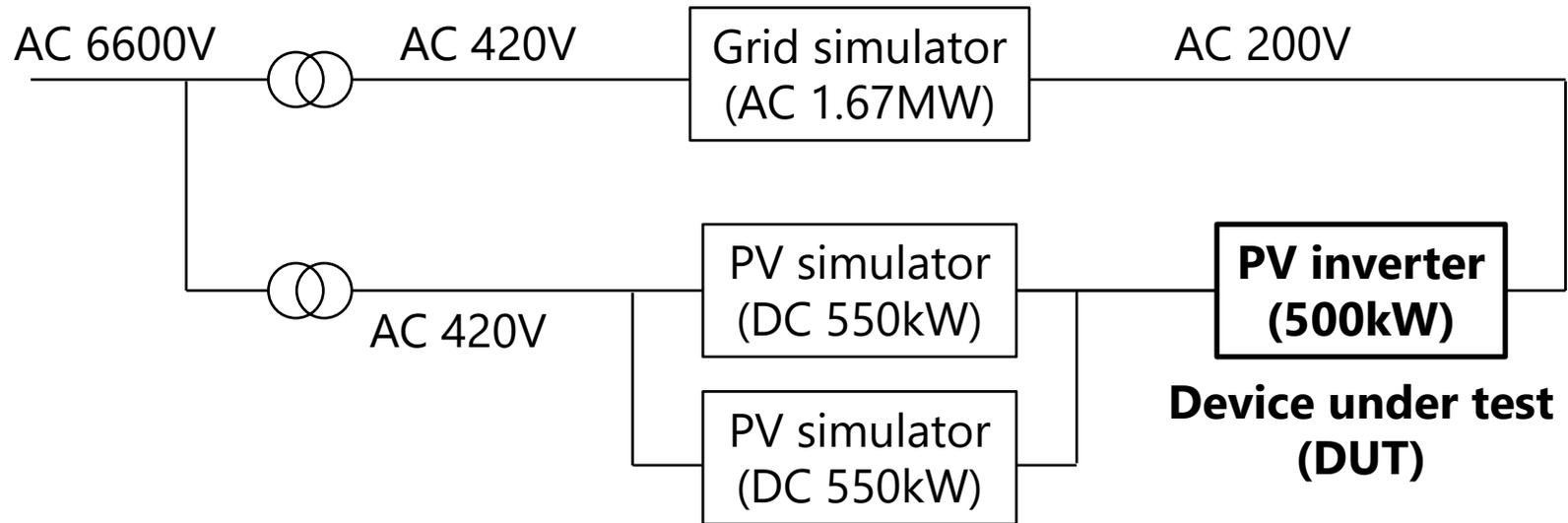
<https://www.renewable.pr.aist.go.jp/ent/>

Example Test of Smart Inverter @FREA-G

- Tested voltage ride through and Volt-Var functions of smart inverter
- Test condition
 - 3LG fault: three line to ground fault occurs in transmission line
 - Fault removal: detect over current and open the circuit breakers
 - Evaluation: compare the grid voltage w/ and w/o Volt-Var function
- Power system model

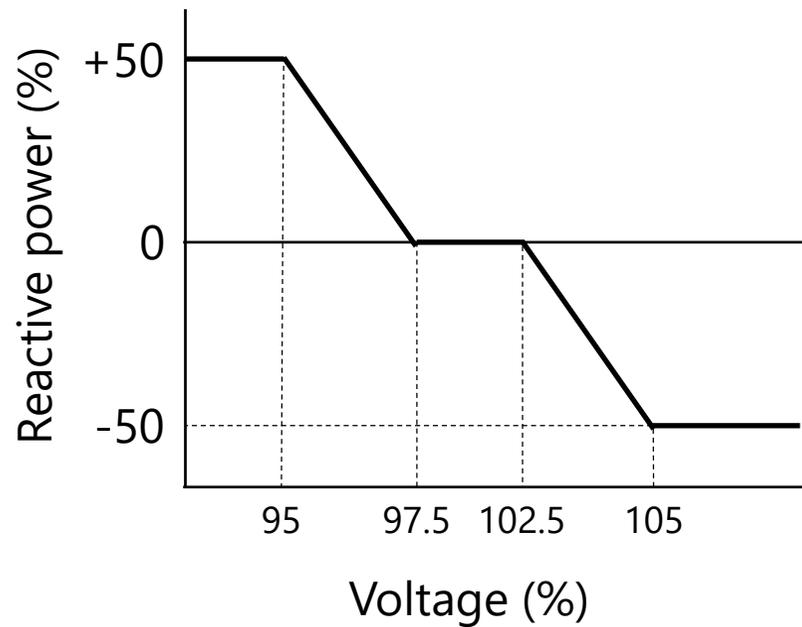


Experiment Setup for Testing Volt-Var Curve Setting

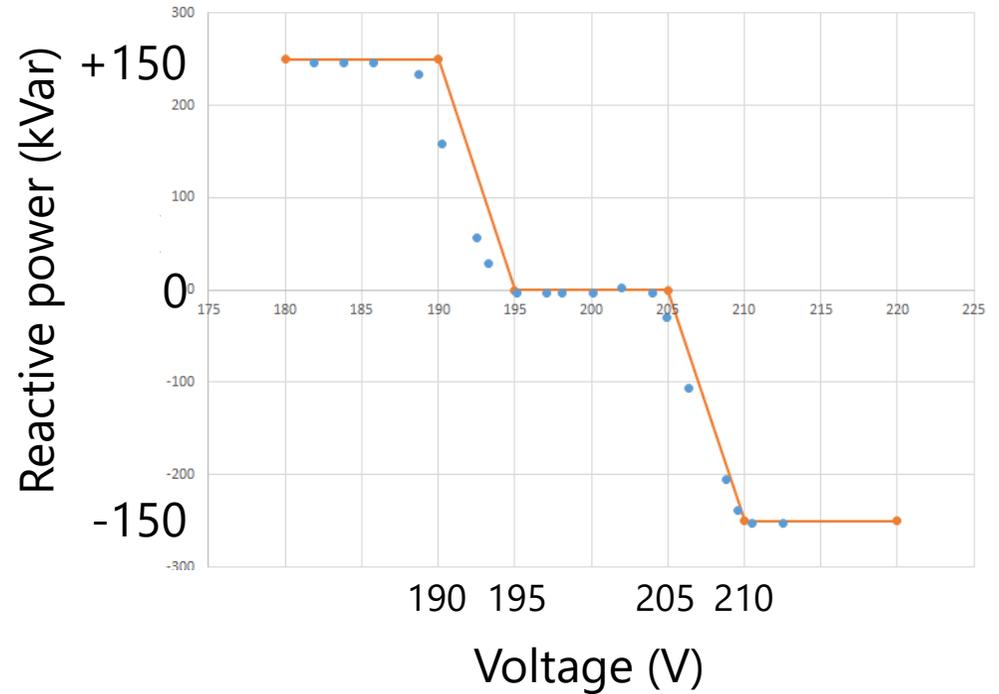


Testing Result of Volt-Var Curve Setting

■ Setting

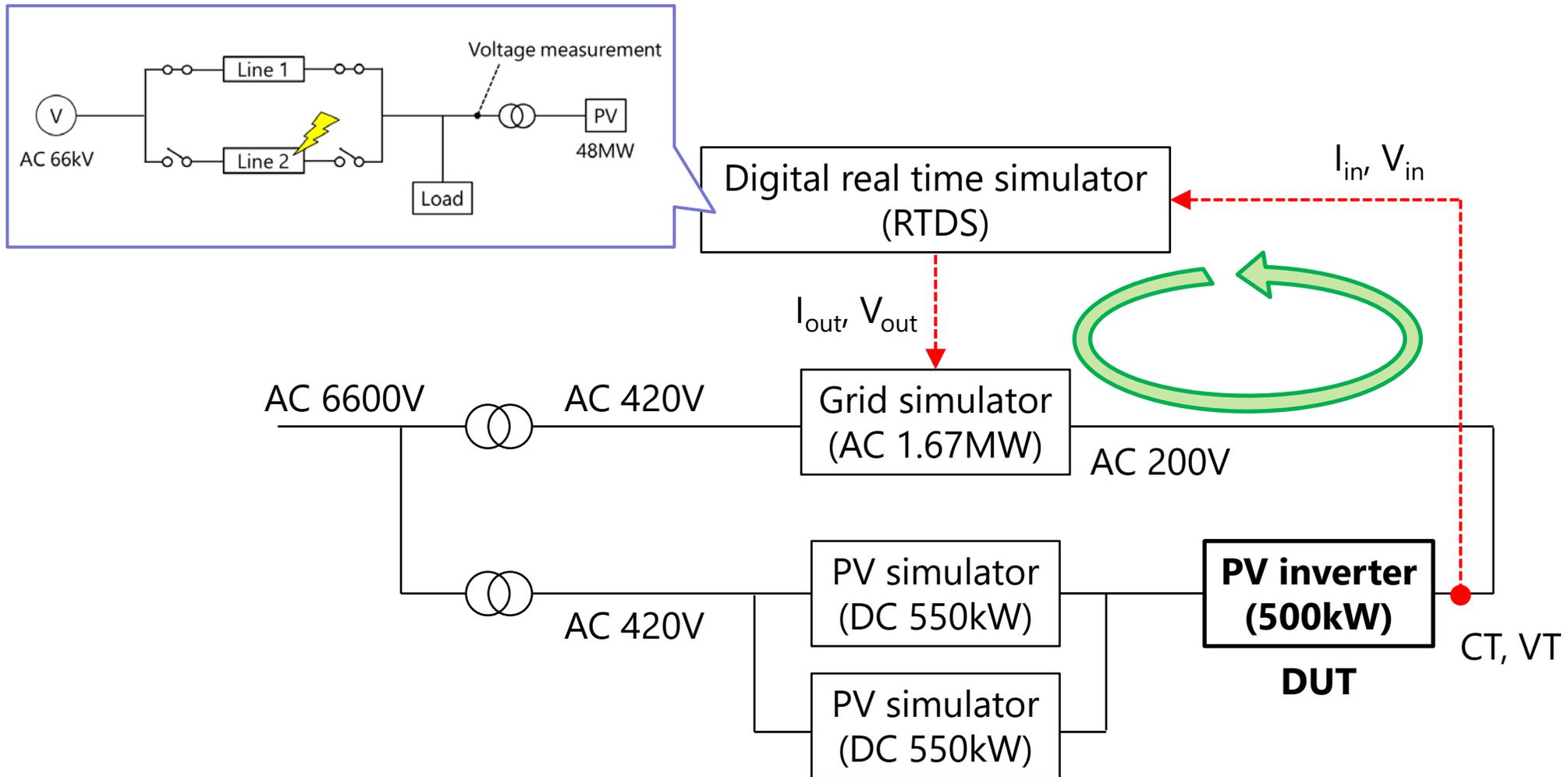


■ Measurement



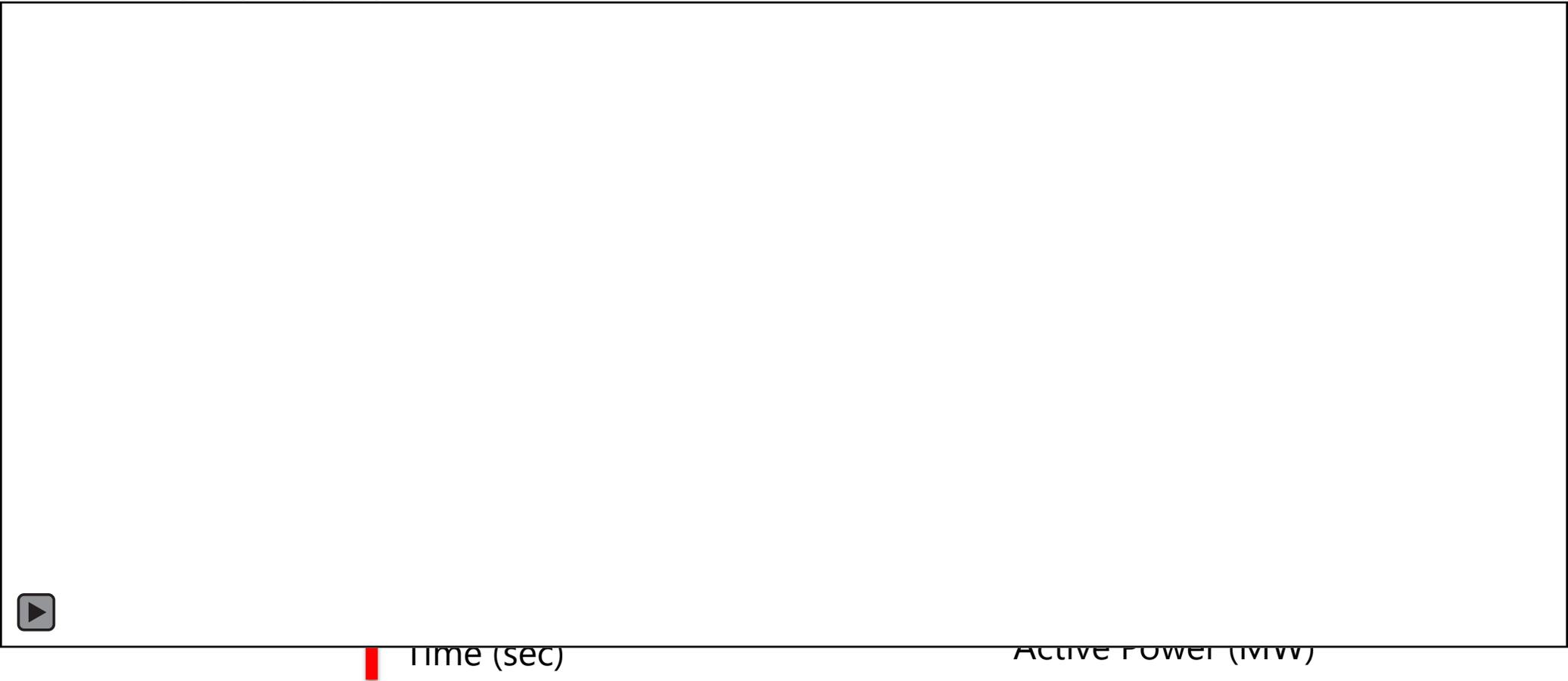
Measurement points are within the permissible range

Experiment Setup of Power Hardware-In-the-Loop (PHIL) Test



Volt/Var Function after LVRT

3LG Fault



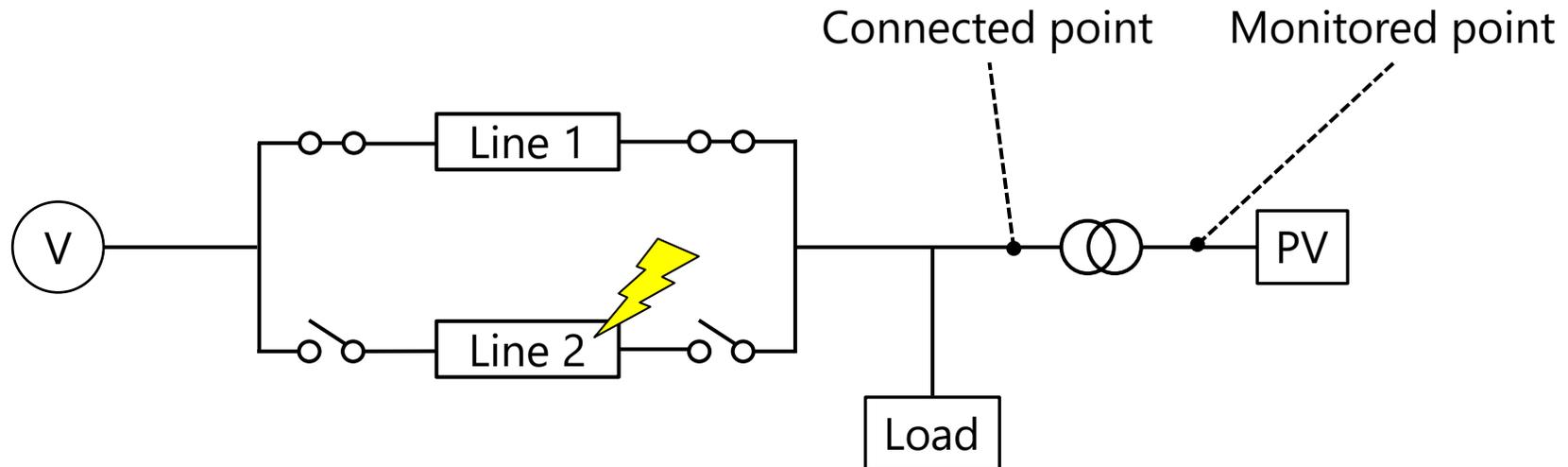
Line 2 CB Open

- w/ Volt/Var function
- w/o Volt/Var function

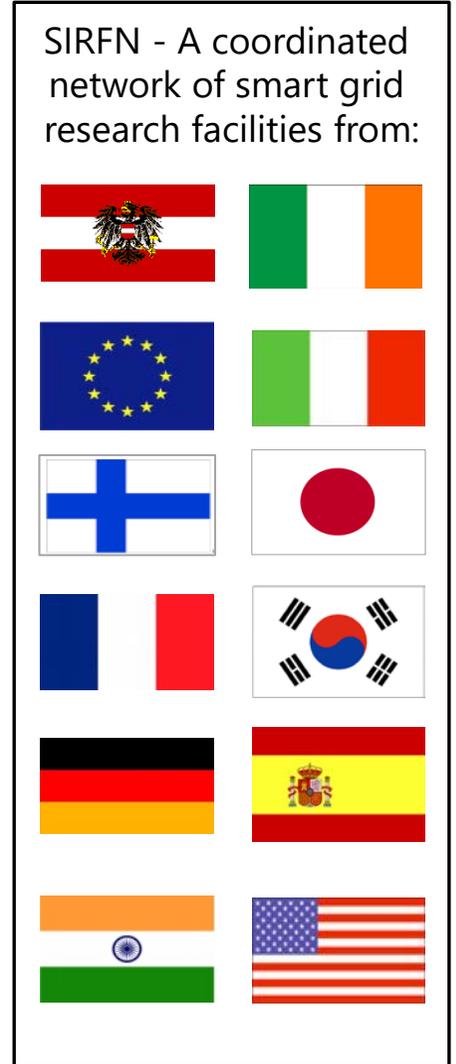
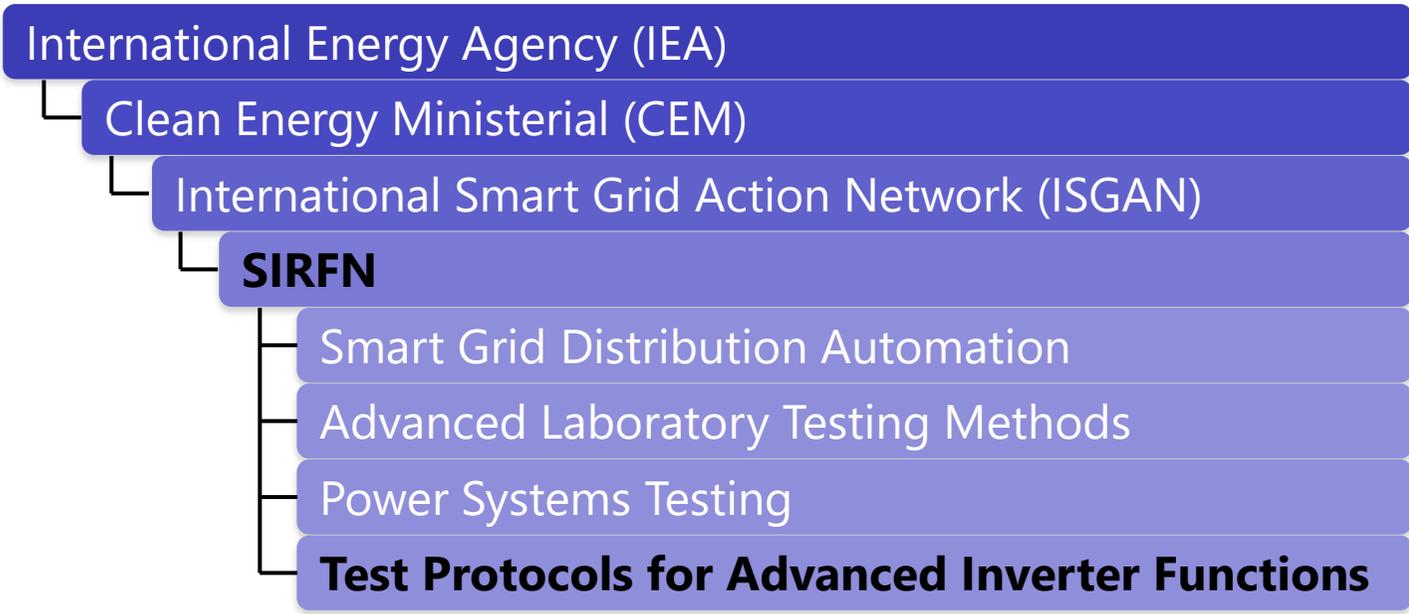
Discussion

- How to determine the requirement of grid support function
 - Difference of monitored and connected point of inverter
 - Time related parameters: ramp of output, time constant

Compensation amount of active and reactive power will be different



SIRFN Smart Grid International Research Facility Network



- Purpose of SIRFN
 - Develop and demonstrate a consensus-based interoperability certification standard for advanced DERs
- Our activities
 - Develop common test protocol for DER
 - Develop automated testing platform
 - Discuss about international consistency