Complete System-Level Efficient and Interoperable Solution for Microgrid Integrated Controls (CSEISMIC)

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ORNL DECC Lab Facilities

Directly connected to the ORNL campus distribution system, ORNL Distributed Energy Control and Communication (DECC) Lab has state-of-the-art distribution system R&D facilities:

- 50 kW and 13.5 kW PV systems
- 25 kW, 50 kWh Battery
- 30 kW microturbine
- Two 60 kVA and one 20 kVA smart inverters
- 200 A power flow controller
- Two 500 kW and one 45 kW R load banks
- 36 kW programmable resistive load bank
- 375 kVar inductive load bank
- Synchronous and induction machines
- Programmable power system protection relays

ORNL DECC Lab facilities

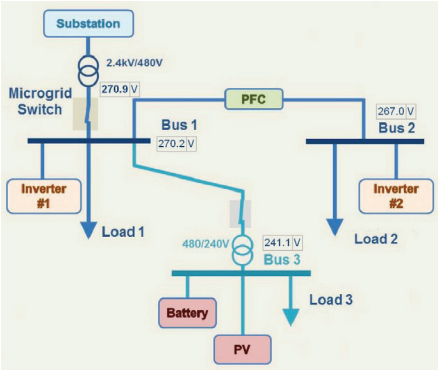
Microgrid: Future Distribution System Solution

- Enable high-performance low-cost solution for high-penetration of distributed energy resources, electric vehicles, and energy storage integration
- Improve system reliability, stability, and efficiency
- Incorporate legacy components and systems as well as deploying the most advanced technologies in renewable energy, energy conversion, communications, and controls
- Provide smart and simple monitoring, operation, and pricing tools for the utilities to interface large amount of distributed components
- Full control and energy management system (EMS) for the users to optimize their energy consumption and generation
- Adaptive relay protection to accommodate new components and new operation conditions.

ORNL Microgrid

An Operational Microgrid:

- Three buses, 480V/240V/208V, three-phase and single-phase
- Two inverters, one PV, and one battery with total generation capacity of 160 kW
- Programmable R/L load banks can provide sudden large load changes as well as second-to-second residential/ commercial load profiles
- Power flow controller can change the line impedance between the buses by a factor of 30



ORNL microgrid one-line diagram

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ORNL Microgrid Future Additions:

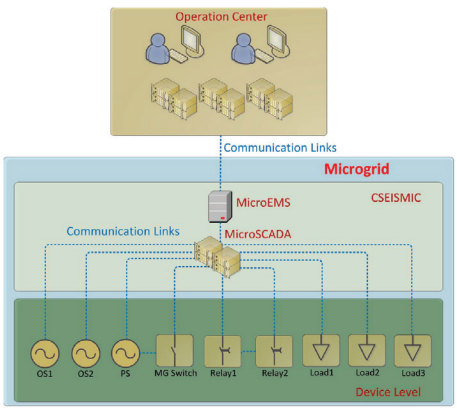
- MAXLab, the building technology research facility, as another bus with more diversified loads
- Reconfigurable system with both loop and radial topologies
- More renewable and rotating machine based DER
- More energy storage

ORNL Microgrid Controller: CSEISMIC

ORNL has developed a Complete System-level Efficient and Interoperable Solution for Microgrid Integrated Controls (CSEISMIC). It monitors and controls the microgrid components through communication links to perform both real-time controls and energy management. It is also the interface between the microgrid and the power system operator/energy market for the microgrid to participate in system operation and/or energy market activities.

CSEISMIC Functions:

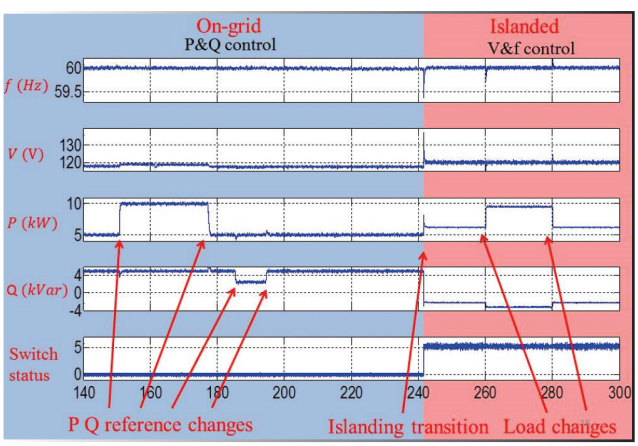
- On-grid operation
- Islanded operation
- Black start capability
- Automatic islanding transition
- Active resynchronization and reconnection
- Adaptive protection
- Microgrid energy management system to optimize energy profile
- Provide ancillary services
- Participate in energy market



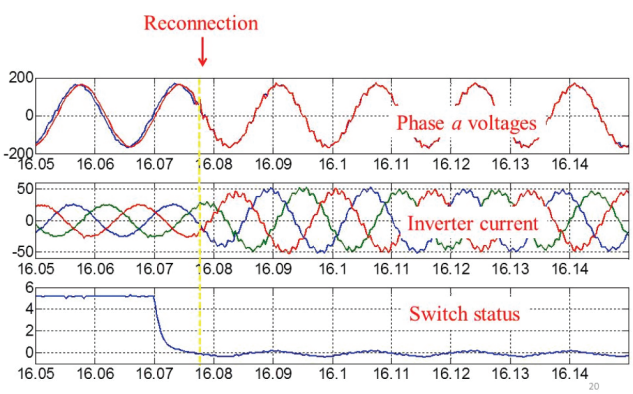
CSEISMIC communication and control architecture

CSEISMIC Innovations:

- Multi-layer communication and control architecture enables the implementation of both centralized and distributed controls to achieve the microgrid performance goals.
- DER controls enable the microgrid to operate in islanded mode and provide uninterrupted power supply during transitions. The three inverter control modes: PQ control, P-f and Q-V control, and closed-loop voltage and frequency control that can be switched from one to another according to system operation conditions.
- Fast communications for the microgrid EMS as well as real time control such as islanding transitions and relay protection.
- Operational multi-objective optimization is developed in microgrid EMS to achieve different energy generation and consumption objectives.



ORNL microgrid islanding testing



ORNL microgrid reconnection testing