

Current State Estimation For Microgrids

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Load Monitoring for Microgrids

- ✓ With the modernization of the electrical systems, the concept of microgrids has emerged as one of the solutions for the future operation of the system as a smart grid.
- ✓ Commercial facilities, as they are owned by single owners, are easier to setup microgrid operation. They also represent one energy-use segment with significant potential to increase energy efficiency and to participate in demand response.
- ✓ Load monitoring is very important for microgrids because it provides essential information for energy management systems to coordinate operation of loads and generators. In addition, this information can be used for equipment condition monitoring, which is another smart feature of the microgrids.

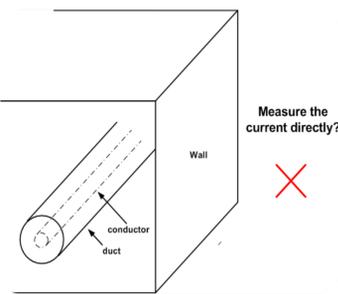
Objective

- ✓ Develop a method to monitor microgrid loads using a set of voltage sensors and state estimation algorithms.

Measurements in a Commercial Facility

The direct solution to monitoring loads is to measure current or power consumed by each load of the facility.

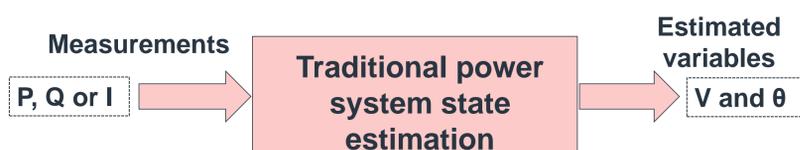
Problem: Measuring load current or power requires accessing to the conductors supplying the loads. This can be difficult or even impossible for facilities that have already been built. This is because the power supply conductors are usually installed in ducts inside the walls and therefore inaccessible.



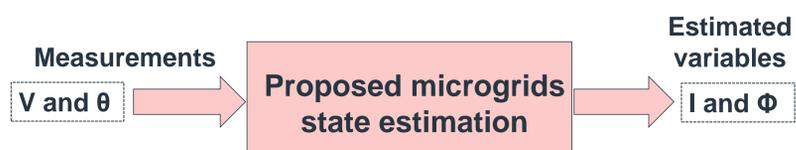
Proposed Solution: Voltages at the load terminals are often accessible and can be measured by distributed voltage sensors. These voltages, combined with the network topologies and parameters, can be used to estimate the load currents through state-estimation-like algorithms.

Microgrids State Estimation

In traditional power systems state estimation, the measurements of active and reactive power are available, and the estimated variables are the voltages at the buses.



For the commercial facilities, due to inaccessible conductors, the measurements of power or currents are not available, however the voltages at loads terminals are available. Therefore, a current-based state estimation algorithm is proposed to estimate the load currents using the voltages sensed at the terminals of the loads.



Microgrids State Estimation - Formulation

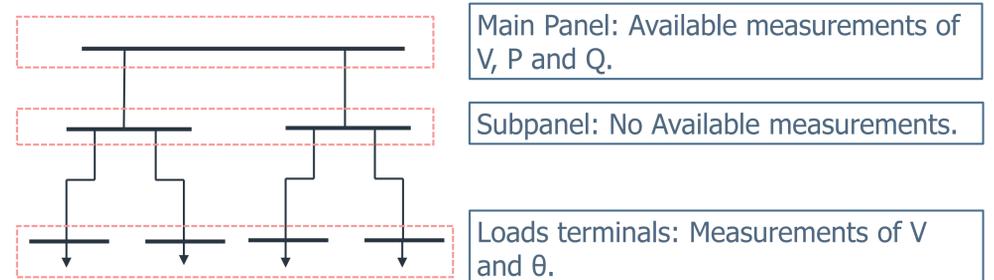
The Weighted Least-Square (WLS) is used to estimate the state variables, which are expressed as:

$$z = h(x) + w$$

$$s.t. c(x) = 0$$

where z contains the measurements; x is state vector; $h(x)$ is a vector of functions relating measurements to state variables; w contains the measurement error vector; $c(x)$ is a vector of functions that model the zero injections as equality constraints.

A simple reduced one-line diagram of a commercial facility is following presented:



- ✓ The measured variables for the SE program are: $\{P, Q, V, \text{ and } \Theta\}$
- ✓ The state variables for the SE program are: $\{I \text{ and } \Phi\}$
- ✓ Zero injection of the currents equality constraints should be considered for the subpanels
- ✓ The initialization of the currents is based on the fact that all branches currents are a combination of the loads currents.

Method Validation

- ✓ The proposed load currents state estimation method was validated for a commercial system.
- ✓ A load flow program was employed to obtain, for the specified loads and main panel voltage, the real values of variables.
- ✓ Then, the measured values are calculated by adding a normally distributed (Gaussian) error on its true value.
- ✓ The average of the errors for the estimated current magnitude and angles were calculated considering 100 simulations.
- ✓ The results revealed that it is a promising alternative direction for monitoring microgrid loads.

Conclusions

- ✓ This project has presented a novel and attractive approach for microgrid load monitoring.
- ✓ The main idea of the proposed method is to use easily accessible voltage measurements to estimate load currents.
- ✓ The proposed technique represents a good solution for microgrid facilities where the load conductors are inaccessible for current sensing.
- ✓ The idea of using voltages to estimate currents as presented in this paper has some other applications. For example, it could be used to monitor home appliance behavior by using distributed voltage sensors installed at various locations of a home.