**Abstract**

A state machine is proposed as the solution for an automated microgrid energy management system (EMS) to improve transient performance during transition operations. It characterizes microgrid operation by seven states that cover all the operating modes: two for steady-state operation (grid-connected and islanded), four for transition operation (preparing for disconnection, transitioning to islanding, preparing for reconnection, and transitioning to grid-connected), and one for emergency operation (black-start operation). A unique dispatch algorithm is developed for each state to achieve the control objective, and the transition function is implemented in the state machine as control logics to transition the system from one state to the next. The feasibility and effectiveness of the developed state machine is validated by simulation in MATLAB with an example microgrid, and the test results show excellent performance of the state machine to achieve the target control objective in each state and to improve the system’s transient performance during transition operation.

**Design of States of Microgrid Transition Operation State Machine**

- Seven states: two steady-state states, four transition states, and one emergency state
- Transition logic to transfer from one state to the next.

**Design of Transition Logic**

- Defined based on recommendation from IEEE Std 2030.7
- 13 paths for transition operation.

**Highlight**

1. A state machine-based EMS classifies microgrid operation into seven states and achieves fully automatic operation.
2. The transition function is implemented as the control logics to transition the system.
3. The dispatch function adopts a hybrid approach: optimization algorithms for steady states and rule-based algorithms for transitions.

**Two Core Functions in a Microgrid EMS Based on IEEE Std. 2030.7**

- Dispatch function: dispatches assets with certain operation modes and set points
- Transition function: manages the transitions between grid-connected and islanded mode, ensuring dispatch is adjusted for a given state.

**Simulation Results I**

- Transition Operation Test: grid-connected → preparing for disconnection → transition to islanded → preparing for reconnection → transition to grid-connected → grid-connected

**Simulation Results II**

- Emergency Operation Test: external fault initiated in grid-connected mode

**Conclusions**

A state machine-based EMS is developed to manage operation of microgrid for full automation. This state machine integrates dispatch function and transition function into one control frame. The results show that the developed state machine can transition from one state to the next correctly and timely, and the dispatch function can respond to the DNO’s command/grid disturbances correctly, achieving smooth microgrid transition operation and performing black start if needed.

**Additional Reading**