SAND2022-7640C

Sandia National Laboratories

49th IEEE Photovoltaic Specialist Conference (PVSC)
June 5 – 10, 2022
Philadelphia, Pennsylvania

Grid-Forming Inverter's Capability to Support Dynamic Microgrids with High Penetrations of Photovoltaics Systems

R. Darbali-Zamora[1], C. Birk Jones[1], Matthew S. Lave[1], and Erick E. Aponte-Bezares[2]

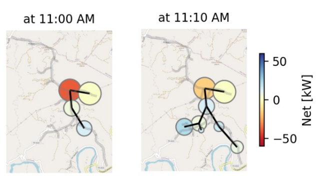
[1]Sandia National Laboratories, Albuquerque, New Mexico, 87185, USA [2]University of Puerto Rico-Mayaguez, Mayaguez, Puerto Rico 00682, USA

Introduction

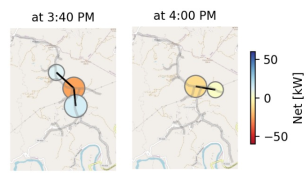
Grid-forming (GFM) inverters can support dynamic microgrids with photovoltaic (PV) resources that expand and contract depending on available resources. To work, a GFM inverter must maintain appropriate voltage and frequency as the magnitude of PV output and loads change quickly during a switching event that acts to reduce the difference between generation and consumption. The simulation effort, described here, studies the potential capabilities of the GFM to support variable PV generation and fast changes in the microgrid's size that either increase or decrease the systems size.

Microgrid Switch Control Methodology

The microgrid expand and contracts its boundaries so that the difference between load and generation is minimized and capable of support from a GFM inverter placed a the critical load.



Example operations of the dynamic microgrid size reduction.



Example operations of the dynamic microgrid size expansion.

Distribution Feeder Model

Corcovada is a small community in the mountainous region of the municipality of Añasco, located to the West of Puerto Rico, with a population of 627 [2010].

The community powers a water pump for drinking water with a solar plus battery system. Potentially, this system could be expanded to include other critical and non-critical loads using the proposed "breathable" microgrid.

To test this theory, a MATLAB/Simulink model represents the distribution feeder with 50 buses, 48 lines, 43 single-phase transformers, 15 single-phase grid-following PV inverters, a three phase GFM inverter, 36 residential loads, and 9 controllable switches.

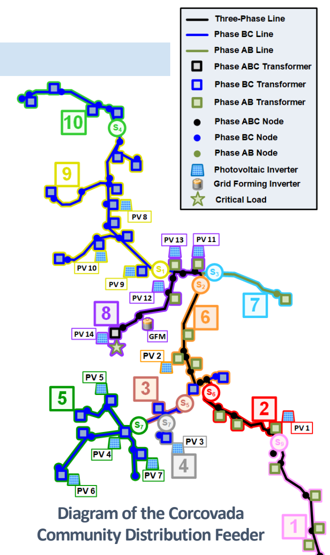


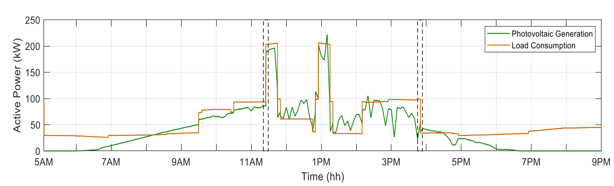
Diagram of the Corcovada Community Distribution Feeder

Simulation Results

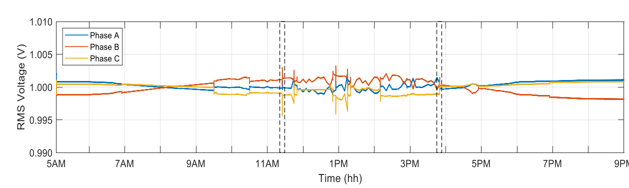
Results demonstrate that when the microgrid altered its boundaries by either increasing or decreasing its size, the voltage had noticeable deviations.

However, in both situations, the GFM inverter's voltage did not change by more than 0.5%.

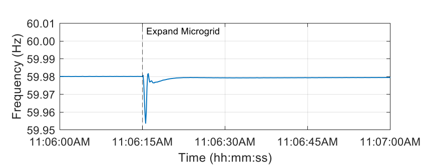
When expanding the microgrid there was a frequency overshoot of less than 0.07% at most.



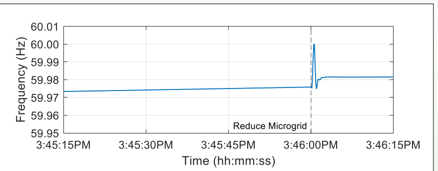
Results for the Total Load demand and Generation within the Main Microgrid.



Results for the GFM Inverters Phase Voltages During Switching Transitions.



Results for the frequency during an expansion.



Results for the frequency during a reduction.

Observations

- Microgrid reconfiguration controls were developed and successful used to determine when and what sections should be connected.
- The GFM inverter was able to provide stable operations as the system changed its boundaries to either include or exclude loads and PV generation.
- Thus showing that dynamic operations is a viable solution for providing a low-cost, PV-based microgrid to remote communities.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology &Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.
SAND No. ____________

Sandia National Laboratories

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.