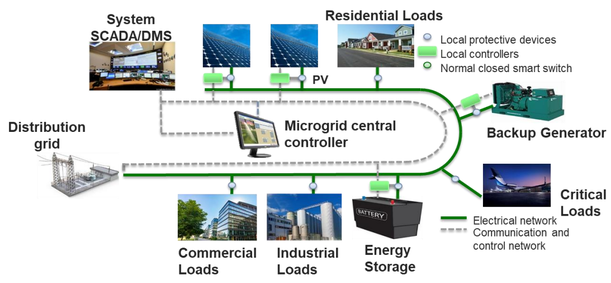
A Converter-Based Battery Energy Storage System Emulator for the Controller Testing of a Microgrid with Dynamic Boundaries and Multiple Source Locations

Dingrui Li[1], Yiwei Ma[1], Chengwen Zhang[1], He Yin[1], Ray Ishita[1], Yu Su[1], Lin Zhu[1], Fred Wang[1,2], Leon Tolbert[1]

[1]The University of Tennessee, Knoxville [2]Oak Ridge National Laboratory

Background and Motivation

- Microgrid (MG) with dynamic boundaries and multiple source locations is a future MG concept that can bring more local flexibility and resiliency
- Controller is a core component in a MG
- Converter-based hardware testbed (HTB) can provide a practical testing environment for MG controller testing
- No suitable BESS emulator is available for controller HTB testing of the MG with dynamic boundaries and multiple source locations

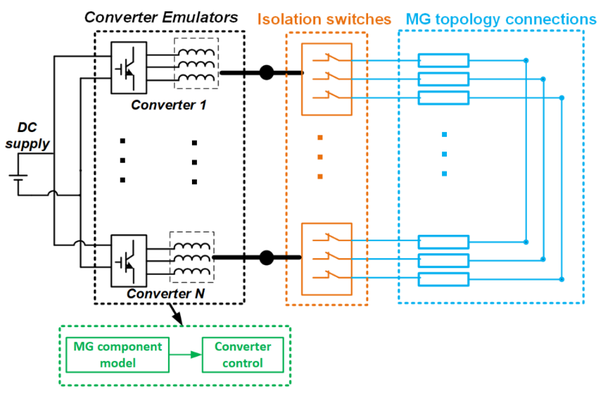


Microgrid controller

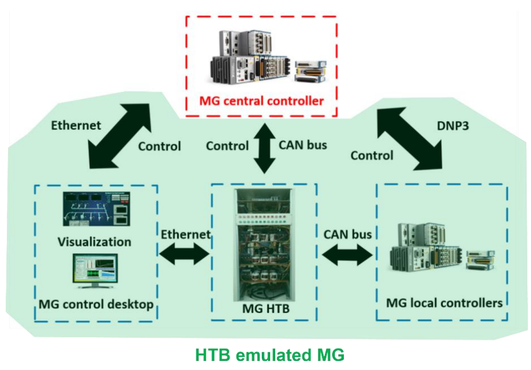
Converter-based HTB

Converter-based HTB

- HTB utilizes a power circulating structure
- MG components are emulated by power converters
- Actual MG controllers are placed in the loop for testing



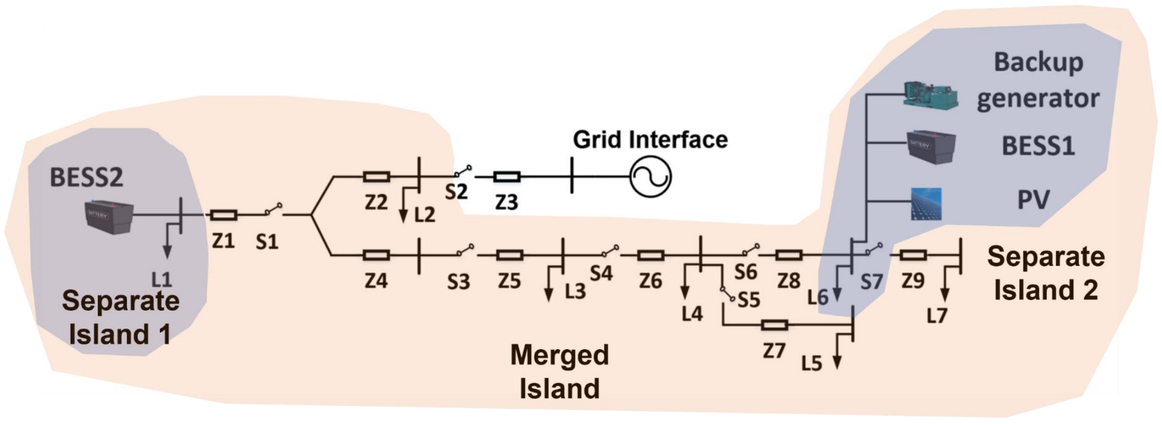
HTB Structure



MG HTB Control Architecture

MG with Dynamic Boundaries and Multiple Source Locations

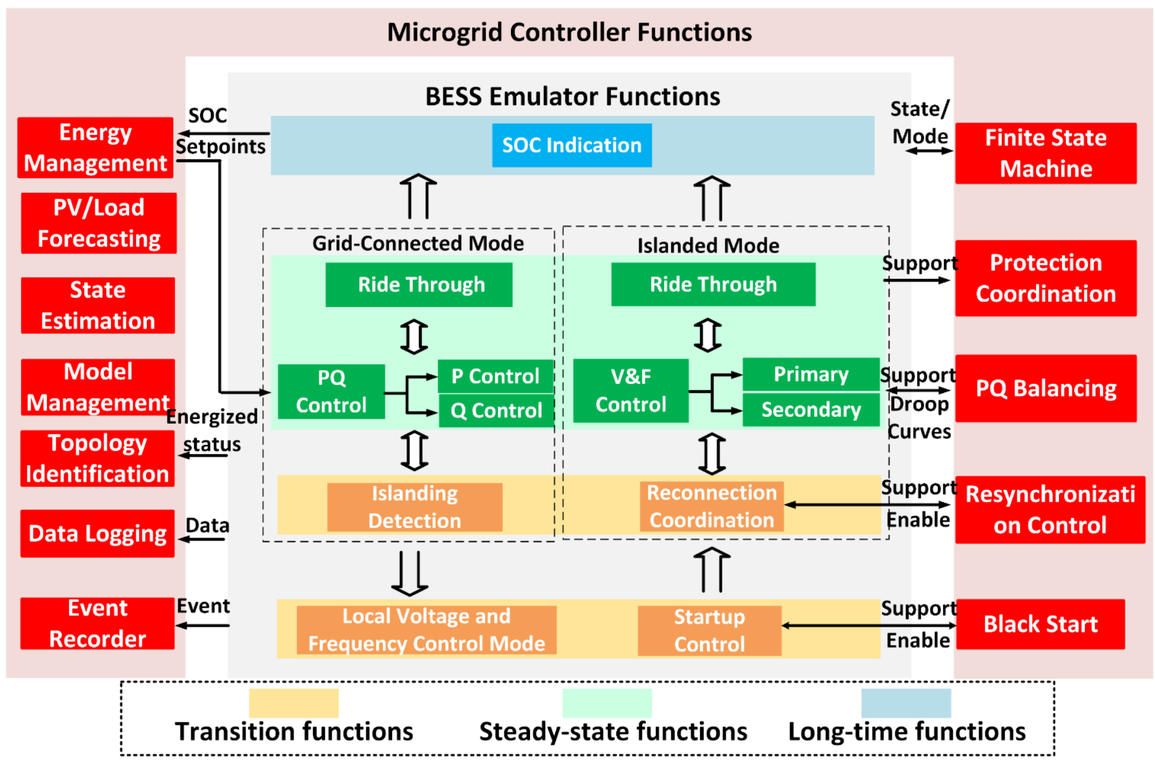
- Microgrid boundary can be expanded or shrunk based on available DER power
- Multiple islands can be formed in the islanded mode
- This microgrid has more complicated transitions
- Microgrid controller functions include long-time functions, steady-state functions and transition functions



BESS Emulator Development

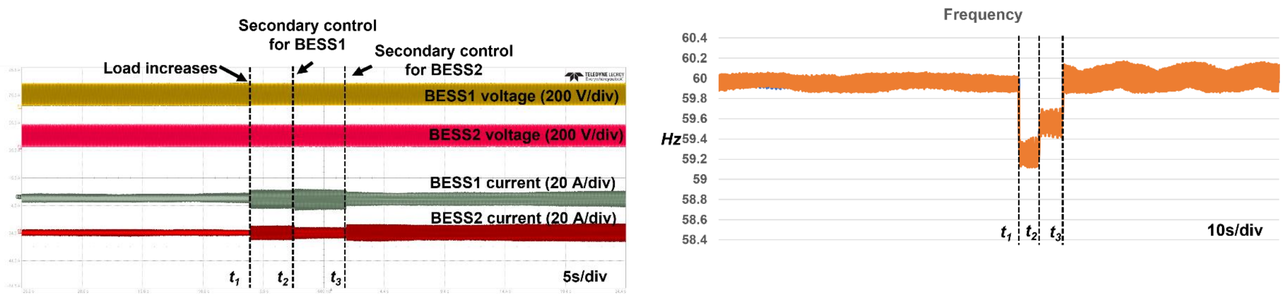
- Requirements of different functions in the MG controller are considered in the development of BESS emulator

Function type	Function block
Long-time functions	Energy management
	PV/ load forecasting
Steady-state functions	Finite state machine
	PQ balancing
Transition functions	Planned islanding control
	Reconnection control
	Black start
	Protection coordination

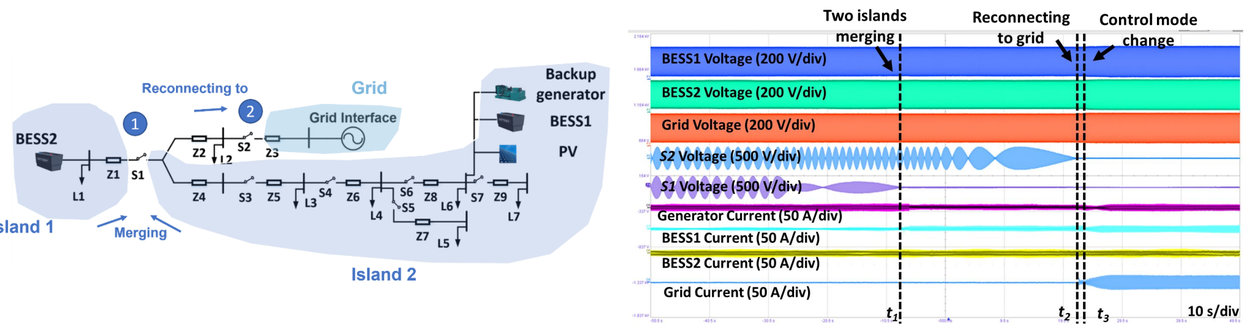


Experimental Demonstration

- Developed BESS emulator is validated on HTB first
- The developed BESS is used to support the MG controller testing



BESS emulator's frequency regulation function



Reconnection testing of MG controller on HTB

Conclusion

- A BESS emulator is developed for controller HTB testing of a MG with dynamic boundaries and multiple source locations
- The BESS emulator can support different operation conditions
- Practical environments of HTB are considered in the development

CHANGING WHAT'S POSSIBLE