

## **Nonlinear Control for Plug-and-Play Operation of Smart Microgrids**

Xia Miao ([xmiao@mit.edu](mailto:xmiao@mit.edu)) and Rupamathi Jaddivada ([rjaddiva@mit.edu](mailto:rjaddiva@mit.edu))

Microgrids are gradually becoming a backbone of future urban infrastructures. However, their integration still presents a major challenge. In particular, high penetration of intermittent resources creates operating problems of stand-alone microgrids equipped with constant gain controllers during unexpected faults in the utility grids. Current solutions to avoiding these problems are either to install large batteries to cancel the effects of disturbances, and/or to limit the use of PVs and other clean resources. In extreme conditions when an islanded microgrid cannot serve its load fast protection would interrupt electricity service to customers.

Our basic research question is whether it would be possible to operate during large bounded disturbances by minimizing the need for expensive storage and service interruptions. We propose a plug-and-play control approach as a possible way of achieving this goal. The approach is to design strictly passive closed-loop components for given disturbance bounds. This is done using the transformed state space which represents stored energy, and power of the component, and the remaining internal states. When such components are interconnected as a microgrid, the higher level coordination is managed without requiring information exchange about the internal states of components. Only information about power and energy is required. The stability of the interconnected system with such closed-loop passive plug-and-play components is ensured by meeting well-known passivity conditions of the interconnected system. Our ongoing research concerns design of higher-layer control with particular interest in distributed implementation. Proof-of-concept of the proposed plug-and-play control approach is shown to demonstrate enhanced performance of microgrids during sudden topology changes in cases when today's controllers fail to stabilize the microgrid and protection must disrupt electricity service.