Low-Inertia Microgrids with High Renewable Penetration

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Summary:

Power electronic inverters will play an integral role in future power systems since they are necessary to interface any dc device, such as photovoltaics, batteries, and fuel-cells, to the ac power grid. A host of complex challenges will be faced by the engineering community as the power system evolves to include an increasingly heterogeneous mix of energy sources and higher levels of intermittent renewable energy sources. To enable simple and scalable solutions, a bottom-up approach to system design is promoted which relies on adaptive, modular, and self-organizing power electronics. In this presentation, we focus on small-scale ac power systems, referred to as microgrids, which are powered by inverter-interfaced energy resources. Challenges associated with microgrids include: i) minimizing communication between inverters, ii) maintaining system stability and synchronization in spite of load variations, iii) regulating the system voltage and frequency, and iv) ensuring the inverters share the load in proportion to their power ratings. To address these challenges, we introduce a method called virtual oscillator control which serves as a viable solution for controlling and synchronizing a collection of inverters without communication. Synchronization phenomena in complex networks of coupled oscillators have been studied extensively in a variety of disciplines such as systems biology, physics, and chemistry. Drawing inspiration from these diverse research areas, the premise of virtual oscillator control is to program power electronic devices to emulate nonlinear oscillators. A system with virtual oscillator control is self-organizing in the sense that the inverters synchronize their ac outputs, share the load, and the system collectively maintains its voltage and frequency without any supervisory control; a stable power system emerges innately by design. Experimental results are presented to validate the concept.