Integration of Next-Generation Power Electronics with Multidisciplinary Cyber Physical Smart Grid

ABSTRACT

The architecture of tomorrow's power grid will be vastly different than it is today. To begin with, it will not be solely a conventional radial power flow system but an integration of existing centralized generation and new (and increasingly-penetrating) distributed generation, based primarily on renewable/alternative and other carbon-neutral technologies. Yet another major difference is going to be the pervasive real-time awareness of this grid power-flow mechanism and apparatus leading to smart, sustainable, and secure distributed power management. A massive undertaking is underway for realizing such a sustainable smart grid using multi-disciplinary collaborations and initiatives. Even though the domain of cross-disciplinary expertise needed for this gigantic effort is huge, areas of high priorities - encompassing solid-state power electronics and protection, distributed energy resources, distributed control, ubiquitous sensing, pervasive computing and data management, network optimization and security - have begun to emerge.

Towards that end, in this presentation, the speaker, starting with an overview of the smart grid, will identify and outline ongoing and forthcoming opportunities and research challenges for next-generation power electronics. Follow-up discussion will focus on issues and mechanisms associated with the integration of this solid-state power-conversion technology with the overall cyber-physical energy system. Subsequently, two specific research frontiers will be discussed in details. One, that addresses the design and synthesis of novel high-frequency-link power-conversion systems for microgrid and macrogrid applications by simultaneously considering cost, efficiency, power density, and reliability. The other, that relates to the robust and high-performance operation of such power-electronic systems using new concepts of switching-sequence and switching-transition controls. Scalability of these power-electronic controls for clusters of homogenous and heterogeneous interactive power networks by merging control and communication will also be discussed and demonstrated. Finally, critical conclusions will be drawn, based on the general and specific observations, to formulate a vision for needed smart-grid research via cohesive integration of cross-disciplinary transformative inventions and innovations.