

Energy Networks and Control Systems – Interplay of Architecture, Dynamics and Computations

The area of energy processing, which includes power electronics, electric drives and power systems, is at a crossroad. Its challenges are both external (contribution to climate change, nonfunctional markets) and internal (inability to integrate renewable sources and efficient loads). The promise of energy processing comes from a growing array of potentially transformative technologies that currently exist in power electronics, distributed sensing, and cyber-physical control systems. Other supporting technologies, such as battery storage and Internet of Things, stand at the cusp of advancement that could radically change the long-standing assumptions regarding feasible system architectures.

The first talk of the series will review available energy technologies, and outline salient features of the existing energy systems. The second part will present a more personal view, and introduce the dynamic phasor approach to modeling and analysis of transients in electric energy systems. The approach has lately received a good deal of attention in the energy systems community. Some recent extensions involving filter banks will also be presented. The third part will focus on the concept of reactive power which is fundamental to all ac energy systems. We start by reviewing well known facts about reactive power definition for single-phase single-frequency circuits, and point out difficulties in unbalanced polyphase and multi-frequency systems. Next, we present an approach based on geometric (Clifford) algebras that sheds new light on these old problems, and allows for a unified treatment. We also review more recent developments of “instantaneous” reactive power and propose dynamic phasors as a tool that systematically extends steady-state concepts to transients. We plan to sprinkle the talk with historical facts and connections with various areas of engineering and applied mathematics. The fourth and final talk of the series is meant as a coda to the first one. It will outline desirable future developments in energy systems with an emphasis on integration with water and other infrastructural systems and on architectural aspects of distributed control in electric energy and power electronic systems.

Aleksandar M. Stankovic obtained his Ph.D. degree from Massachusetts Institute of Technology in 1993 in electrical engineering. He presently serves as Alvin H. Howell Professor at Tufts University; he was with Northeastern University, Boston 1993-2010; he is a Fellow of IEEE and serves as an Associate Editor for IEEE Transactions on Power Systems. He has previously served Transactions on Smart Grid, on Power Systems and on Control System Technology in the same capacity since 1996. He has held visiting positions at the United Technologies Research Center (sabbaticals in 2000 and 2007) and at L'Universite de Paris-Sud and Supelec (in 2004). He is a co-editor of book series on Power Electronics and Power Systems for Springer.