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Realistic modeling and analysis of synchronization dynamics in power-grid networks[1]

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An imperative condition for the functioning of a power-grid network is that its power generators remain synchronized. Disturbances can prompt desynchronization, which is a process that has been involved in large power outages. In this talk I will first give a comparative review of three leading models of synchronization in power-grid networks. Each of these models can be derived from first principles under a common framework and represents a power grid as a complex network of coupled second-order phase oscillators with both forcing and damping terms. Since these models require dynamical parameters that are unavailable in typical power-grid datasets, I will discuss an approach to estimate these parameters. The models will be used to show that if the network structure is not homogeneous, generators with identical parameters need to be treated as non-identical oscillators in general. For one of the models, which describes the dynamics of coupled generators through a network of effective interactions, I will derive a condition under which the desired synchronous state is stable. This condition gives rise to a methodology to specify parameter assignments that can enhance synchronization of any given network, which I will demonstrate for a selection of both test systems and real power grids. These parameter assignments can be realized through very fast control loops, and this may help devise new control schemes that offer an additional layer of protection, thus contributing to the development of smart grids that can recover from failures in real time.

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