DY 45: The Physics of Power grids (joint session DY/SOE)

Time: Thursday 10:30–11:15 Location: H6

DY 45.1 Thu 10:30 H6

Comparison of coupled nonlinear oscillator models for the transient response of power generating stations connected to low inertia systems — Marios Zarifakis[1], William Coffey[2], Yuri Kalmykov[3], Serguey Titov[4], •Declan Byrne[2], and William Dowling[2] — [1]Electricity Supply Board, Dublin, Ireland — [2]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [3]Laboratoire de Mathematiques et Physique (EA 4217), Universite de Perpignan Via Domitia, F-66860, Perpignan, France — [4]Kotel'nikov Institute of Radio Engineering and Electronics of the Russian Academy of Sciences, Vvedenskii Square 1, Fryazino, Moscow Region 141120, Russia

Coupled nonlinear oscillators, e.g., Kuramoto models, are commonly used to analyze electrical power systems. Recently the cage model from the statistical mechanics of liquids has also been used for the modelling of the dynamics of synchronously connected generation stations. It appears that while the Kuramoto model is good for describing high inertia grid systems, the cage model allows both high and low inertia grids to be modelled. This is demonstrated by comparing both the synchronization time and relaxation towards synchronization of each model of power generating stations by treating the model equations of motion via a common framework rooted in the dynamics of many coupled phase oscillators. A solution of these equations via matrix continued fractions is implemented rendering the characteristic relaxation times of a grid-generator system over a wide range of inertia and damping.

DY 45.2 Thu 10:45 H6

Enhancing power grid synchronization and stability through time delayed feedback control — •Halgurd Taher[1,2], Simona Olmi[2,3], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Inria Sophia Antipolis Méditerranée Research Centre, 2004 Route des Lucioles, 06902 Valbonne, France — [3]CNR - Consiglio Nazionale delle Ricerche - Istituto dei Sistemi Complessi, 50019, Sesto Fiorentino, Italy

The increasing inclusion of renewable energy sources into the power grid brings new challenges for its stable operation, due to the presence of various forms of perturbations which may possibly harm stability and synchronization. In this talk asynchrony of single nodes in power grids is investigated using real data of the sparsely connected German high-voltage transmission grid. Based on time-delayed feedback control, diffferent control strategies are proposed and compared. The strategies not only take into account solitary states, but also the Lyapunov vector corresponding to the largest (positive) Lyapunov exponent. Starting from an unstable state out of synchrony, we are able to frequency-synchronize and stabilize power grids by just controlling a small set of nodes. The numerical calculation of the Lyapunov spectrum allows us to explore the mechanism behind the control-induced resynchronization transition.

DY 45.3 Thu 11:00 H6

Control of synchronization in two-layer power grids — •Carl H. Totz[1], Simona Olmi[2], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, D-10623 Berlin — [2]INRIA Sophia Antipolis Méditerranée, 2004 Route des Lucioles, 06902 Valbonne, France

The dynamics of a two-layer network modeling the Italian high voltage power grid is investigated: the first layer represents the generators and consumers, while the second layer represents a dynamic communication network between generators that serves as controller of the first layer. The dynamics of the power grid is modeled by the Kuramoto model with inertia, while the second layer provides a control signal P_i^c for each generator to improve frequency synchronization within the power grid.

We investigate different realizations of the communication layer topology and different control methods. The two-layer system is tested for different perturbation scenarios (disconnecting some generators, increasing demand of consumers, generators with stochastic output) and, irrespectively of the applied perturbation, we find that the control scheme aimed to synchronize the frequency of the generators with the consumers is very efficient against almost all perturbation scenarios.