SPRING 2021: Master thesis on stability and control in power systems

Department of Automatic Control, LTH - Lund

Supervisor: Taouba Jouini (taouba.jouini@control.lth.se, KC4, Office: 3:S14)

Type: Master thesis in network synchronization with application to power systems

Start date: **01 Januar 2021** - (recommended but flexible starting date)

Description: The major shift in power generation from conventional synchronous machines to renewables led to the study of problems of network stability composed mainly of DC/AC converters mimicking the electro-mechanical interaction of synchronous machines with the grid. Power system stability is at the heart of understanding of operation of the electrical grid. This amounts to the ability of an electric power system, for a given initial operating condition, to regain state of desired operation, after being subjected to disturbances. These disturbances are on the generation-side, where renewables are known for their stochastic behavior and/or on the consumption-side, where the grid is subject to common failures (voltage collapse, line outage, etc.)
This master thesis aims to study the different control paradigms developed so far to maintain the grid at synchrony and proposes a new method/approach/controller to increment existing control architecture with favorable features to reject disturbances and hence improve their performance. The proposed method achieves synchrony and endows the grid with resilience against disturbances. This must be mathematically proven to hold via theorems and lemmata with theoretical guarantees and verified via Matlab simulations on IEEE test bunch.

Tasks: Your tasks will mostly focus on control theory (70%) and will be corroborated by realistic simulations (30%) of power system models. This includes to:

- review existing literature on synchronization problems in multi-agent systems and identify control-theoretic challenges faced by today's grid.
- formulate and solve a control (optimization) problem to counteract some of these challenges
- prove of concept of the developed method via stability analysis
- compare the developed concept to recent control paradigms for DC/AC converters in power system literature
- validate the developed concept via simulations on realistic IEEE models.

Pre-requisites:

- matriculation as a master student at LTH, preferably in Mathematics Engineering or Physics Engineering or a similar discipline.
- good grip of key control theory tools (FRTF15 Control theory, FRTN05 nonlinear control, FRTN30 Network Dynamics, FRTN55 - Automatic Control, Advanced Course)
- maturity with mathematical tools
- good knowledge of Matlab and Simulink

Some references:

1. Foundations and challenges of Low-Inertia Systems,
   F. Milano, F. Dörfler, et al.
2. Grid-forming control for power converters based on matching of synchronous machines,
   T. Jouini, C. Arghir, F. Dörfler
3. A Framework for Distributed and Compositional Stability Analysis of Power Grids,
   S. Baros, A. Bernstein, N. Hatziargyriou
4. Synchronization and Power Sharing for Droop-Controlled Inverters in Islanded Microgrids,
   J. Porco, F. Dörfler, F. Bullo
5. Performance analysis and optimization of power systems with spatially correlated noise,
   T. Jouini, Z. Sun

This work might be concluded with a publication in well-known control journals/conferences in co-authorship with the supervisor.
This thesis is conducted within the framework of the funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No: 834142).