RWTH AACHEN UNIVERSITY

E.ON Energy Research Center
ACS | Institute for Automation of Complex Power Systems

Master-Thesis:

Development of a distributed optimization-based fast frequency control scheme for inverter-based power systems

Context:
The transition from fossil-fueled energy generation towards renewable energy removes a lot of kinetic energy reserves (inertia) from the power system. Exploiting the fast dynamics of inverter-based generation will be vital in ensuring frequency stability and keeping the frequency and rate of change of frequency (ROCOF) within their operational limits. Therefore, in our research work, we focus on the development of primary and secondary control algorithms for fast frequency control of inverter-based power systems. In this field of research, we developed a model predictive controller (MPC) that operates on the secondary control level and in the event of a disturbance (load step or generator outage) supports the frequency recovery. The control algorithm hereby relies on information and measurements from multiple locations in the power system and is therefore considered as a centralized controller. However, distributed and decentralized control approaches are showing significant advantages for the operation of a future power grid, such as avoiding single-point-of-failure and a more flexible scalability than centralized approaches.

Your tasks:
The student shall develop a distributed MPC fast frequency controller based on the centralized MPC algorithm during the first half of the thesis. The centralized MPC algorithm will be provided as well as an introduction to the previously developed use-case of an inverter-based microgrid. A first task of the thesis is to conduct an initial literature survey about decomposition of the centralized optimal control problem and analyze the realization of the coupling terms. Additionally, the student needs to determine the amount and frequency of information exchange that is required between two consecutive MPC runs. The performance of the chosen approach should be evaluated in terms of its scalability and real-time capability.
Depending on the outcomes of the initial task, the direction for the second half of the thesis will be chosen and discussed together with the supervisors. Some of the following directions could be taken:

- The developed distributed MPC algorithm could be extended in terms of additional non-convex constraints and a non-convex problem formulation. The chosen decomposition method would then need to be adapted, re-evaluated and its performance compared to the previous method.

- The algorithm could be evaluated in a co-simulation setup that couples Matlab/Simulink with a network simulator to study the effects of communication systems on the designed distributed controller. The co-simulator is designed in a parallel work.
- Studying the effects of time-delays on the control algorithms. Different methods for delay compensation can be developed and implemented in cooperation with the supervisor.

During the work the student will be supervised and advised by the research associates of the institute. Supervision will be offered in English and German.

Your profile:
- Good knowledge in power systems and control theory
- Matlab/Simulink is a prerequisite skill
- Good proficiency in English

The thesis should be written in English. Students with background in electrical power engineering or control engineering are encouraged to apply.

Contact:

Tobias Heins
Email: tobias.heins@eonerc.rwth-aachen.de
Tel. +49-241-80-49715

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ERC | E.ON Energy Research Center
RWTH Aachen University
Mathieustr. 6, 52074 Aachen, Germany