RWTH AACHEN UNIVERSITY

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

Master Thesis Proposal:

Distributed Virtual Impedance Loop Control for Accurate Power sharing for virtual oscillator based converters in multi-bus microgrids.

Context:

A microgrid is a controllable network that can effectively integrate all kind of distributed generations (DGs) as a utility-friendly customer. A typical microgrid usually consists of DGs like Photovoltaic (PV) generation, wind generation, Energy storage systems (ESS) such as batteries, super capacitors, fly wheel, and distributed (local) loads. Optimal utilization of microgrid will reduce the needs of building new transmission, distribution capacities, reduce power losses in transmission and distribution networks, increase power quality, and create new approaches for using renewable energy resources.

However, the continuous development and deployment of microgrids pose significant technical challenges in terms of system stability and synchronization, voltage and frequency regulation, and load power sharing. Virtual Oscillator Control (VOC) is a new technique, which provides a method to synchronize and control a system of parallel converters without communication, by emulating dynamics of a nonlinear dead-zone oscillator. VOC offers both system-level and component-level advantages. From the system-level perspective, VOC ensures synchronization in connected electrical networks of inverters without any communication, voltage and frequency regulation objectives are verified in a decentralized fashion. At the component level, each converter with VOC can rapidly stabilize arbitrary initial conditions and load transients to a stable limit cycle.

Since the power-sharing accuracy between paralleled connected VO-based inverters is mainly depending on the closed-loop output impedance of the inverters, several control methods are developed to handle this error. Virtual impedance (VI) loop concept is one of the well-known methods which modify the output impedance of the inverter in order to reduce steady-state power-sharing error. However, the conventional VI method cannot be applied to VOC because no reference control signal is used in VOC. Hence, distributed control strategy with minimum communication requirement is needed.

Task:

In this context, the required tasks for a thesis will be:

- Understanding VOC concept and simulation model in MATLAB/Simulink (provided by supervisor)
- Optimal design of multi-agent based VI to support VOC in order to mitigate power-sharing inaccuracy.
- Stability analysis of a system with VOC and proposed VI.
- Verification of the proposed control concept in real-time simulation and *Hardware-in-the-loop* (HIL).
- Investigate the possibility of using proposed VI loop to improved harmonic stability (depends on a time constraint)

The student will receive an introduction to VOC and related materials (including references, basic VOC model and proposed additional control methods) in order to start with the required tasks quickly. The details of the tasks and time plan will be discussed in the first meeting. During the work, the student will be supervised and supported by research associates of the institute.

Your Profile:

- Good knowledge in power system dynamics and control
- Matlab/Simulink is a prerequisite skill.

If you have any question or concern, please do not hesitate to contact me via email or in person.

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