RWTH AACHEN UNIVERSITY

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

Master Thesis Proposal:

Virtual Impedance Loop Control for virtual oscillator based converters in islanded 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) like batteries, supercapacitors, fly wheel, and distributed (local) loads. Optimal utilization of microgrid will reduce the needs of building new transmission, distribution system, 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 term of system stability and synchronization, voltage and frequency regulation, and load power sharing. Moreover, there might be a large number of unbalanced and nonlinear loads in the microgrid which will decrease power quality and cause severe problems on system equipment. Existing control methods relying on communication links between converter controllers, such as Master-Slave and Centralized control, achieve good performance at the cost of intercommunication lines, but limiting system reliability, modularity, and expandability.

Virtual Oscillator Control (VOC), on the other hand, 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 appealing 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 depended on the closed-loop output impedance of the inverters, several control methods are developed to handle this error. Virtual impedance loop (VIL) 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.

Task:

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

- Understanding VOC concept and simulation model in MATLAB/Simulink (provided by supervisor)
- Optimal design VIL to support VOC in order to mitigate power-sharing inaccuracy.
- Stability analysis of a system with VOC and proposed VIL.

- Verification of the proposed control concept in real-time simulation and *Hardware-in-the-loop* (HIL).
- Investigate the possibility of using proposed VIL to improved harmonic stability (depends on a time constraint)

The student will receive an introduction of 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 dynamic and control
- Matlab/Simulink is a prerequisite skill.

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

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Temporary Time plan

Mon No.	Work package	Detail	Note
1	Literature review	- Fundamental of Virtual Oscillator Control method for power sharing between parallel inverters - Technical issues related to unbalanced voltage and harmonics in microgrid: problems and solutions.	
2	Controller design	- Based on one of the control methods proposed on literature, design a generic VOC controller for a certain microgrid. - Based on literature review results, design one of the methods for harmonics and unbalanced voltage mitigation.	
3	Controller implementation	- Implement chosen controllers in Matlab/Simulink	
4	Stability analysis	- Implement stability analysis for microgrid with multiple VOC-based converters working in parallel.	
5	Conclusion	- Finalize results and write thesis	