Karlsruher Institut für Technologie

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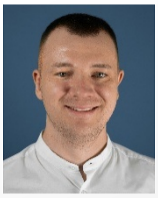

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Start: immediately **Duration:** 6 Months

☐ experimental ☐ application-oriented ☒ theory-oriented

Interests:

☒ Modelling ☒ Simulation
☐ Identification ☒ Controller Design
☐ Neural Networks ☐ Optimization

Master's Thesis

Passivity-Based Control of Constant-Power Loads in DC Microgrids

Motivation

The increasing deployment of DC microgrids - in hospitals and data centers, in industrial facilities, and in off-grid island networks - places growing demands on the stability of these systems. At the same time, the ongoing integration of renewable energy sources (RES) replaces centralised generation with a large number of distributed generation units (DGUs). The RESs volatile and intermittent nature raises the bar for system-level stabilisation, since every connection, disconnection, or fluctuation in power injection can significantly perturb the network dynamics.

Passivity-based control (PBC) enables decentralized stabilisation and plug-and-play operation, making it well suited to this setting. Existing PBC approaches, however, treat loads as black boxes and place all controller design on the source side - an assumption that is not necessary for constant-power loads (CPLs) as they are usually power-electronics based and hence controllable. A framework that renders the CPL bus port passive by designing the load's inner converter controller is absent from the literature.

Task Description

The goal of this thesis is to develop a passivity-based control framework for controllable CPLs, treating the load's inner converter controller as the designable degree of freedom for rendering the load port passive.

Following an introduction to passivity, equilibrium-independent passivity (EIP), and the required basics in DC Microgrids, a structured literature review identifies where existing source-side approaches fall short for load-side design.

The core contribution is the development of a controller for an averaged, dynamic load model that passivates the load bus port. Therefore, an appropriate load model must be defined beforehand. Further contributions are the calculation of the achievable controller bandwidth as a function of the bus parameters, and the calculation of the achievable passivity index. The latter shall be compared with existing source side results. The findings are validated in simulation benchmark studies using Matlab/Simulink, where the load-side controller is compared to existing source-side approaches.

If you are interested or have further questions, feel free to reach out — I look forward to your application.