DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Hierarchical Distributed Control of Active Electric Power Distribution Grids

Location: Pontoppidanstræde 111, room 1.031

Time: Friday 4 October at 10.00

PhD defendant: Karthikeyan Nainar

Supervisor: Professor Jayakrishnan R. Pillai

Moderator: Associate Professor Filipe Faria Miguel De Silva

Opponents: Associate Professor Filipe Faria Miguel De Silva, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Mario Paolone, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland
Professor Henrik Sandberg, KTH Royal Institute of Technology, Stockholm, Sweden

All are welcome. The defence will be in English.

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Abstract:

In Denmark, the electric power system is undergoing a major change to meet the target of 100% renewables based energy system by 2050. In this context, power distribution grids will be operated with fluctuating wind and solar generation, large number of electric vehicles and heat pumps. Proper coordination and control of these distributed energy resources (DERs) will be necessary to prevent network congestion and to maintain quality of service to the customers.

This PhD study addresses the challenges of distribution system operator (DSOs) in the operation of future distribution grids. A hierarchical distributed control framework is proposed for managing the distribution system by utilizing flexibility from DERs. The proposed hierarchical control framework consists of three control levels with medium and low-voltage network controllers operated by DSOs, and DER controllers owned and operated by customers. A linear predictive control method is proposed for the network controllers, which can be implemented either in a centralized or distributed fashion. The proposed predictive control method gets inputs from state-estimation and forecasting algorithms and price signals from electricity markets to calculate the power setpoints of the DERs. Simulation studies conducted using models of Danish distribution networks on Matlab/Simulink show that proposed multi-level control enables cost-effective operation of distribution network.
In the PhD project, flexibility from DERs is used for voltage regulation, peak shaving, increased accommodation of PV power, minimization of network power losses and network congestion management. A novel scheme for network reconfiguration is proposed based on mixed-integer linear programming. An advanced interface among DSOs and the TSO is proposed for utilization of DGs at distribution networks by the TSO for secondary frequency regulation. Simulations are done in Matlab/Simulink and DigSilent Power factory using models of medium and low-voltage Danish distribution networks to validate the proposed methods numerically.

A simple protection scheme is proposed in this PhD study for medium-voltage networks with distributed generation (DG) that addresses the protection-blinding and false-tripping issues. The proposed protection scheme uses adaptive relay settings according to the network topology and connection status of DG. Validation of the proposed scheme is done using Power factory and a real-time digital simulator.