



DEPARTMENT OF ENERGY TECHNOLOGY  
AALBORG UNIVERSITY

## PhD Public Defence

- Title:** Development of Control Strategies for Digital Displacement Units
- Location:** Pontoppidanstræde 111 in the auditorium
- Time:** Monday 17 December 2018 at 13.00
- PhD defendant:** Niels Henrik Pedersen
- Supervisor:** Professor Torben O. Andersen
- Moderator:** Associate Professor Lasse Schmidt
- Opponents:** Professor Birgitte Bak-Jensen, Dept. of Energy Technology, Aalborg University (Chairman)  
Associate Professor Jerome Jouffroy, University of Southern Denmark, Sønderborg, Denmark  
Professor Victor Juliano De Negri, Federal University of Santa Catarina, Brazil

**All are welcome. The defence will be in English.**

**After the defence there will be an informal reception  
in Pontoppidanstræde 111 (coffee room).**



**Abstract:**

The aim of this thesis is to develop control design models of digital displacement (DD) hydraulic units, enabling dynamical analysis and control synthesis. The newly emerging digital displacement technology is an energy efficient digital hydraulic concept for pump and motor units, where numerous pressure chambers are controlled individually by electromechanical actuated on/off valves to obtain the desired displacement throughput. The technology is assessed to have potential as being the core component of future transmission solution for high power renewable energy take-off systems in e.g. wind and wave energy, as well as being a direct replacement to conventional hydraulic pump/motor units.

The research has contributed with an investigation of the underlying challenges related to control of a complex dynamical system comprising of nonlinear, continuous, discrete, binary and operation altering dynamical elements. It is found that within a limited operation region, the fundamental dynamical behavior may be described by both continuous and discrete approximations. Controller synthesis based on both deterministic and stochastic optimal state feedback control, as well as model predictive strategies has been applied to obtain the desired performance. More complex dynamical system theories have been studied in the aim of obtaining a more accurate and general control design model description. Hybrid dynamical system theory can describe the dynamics of such, but control law establishment for such system is based on stability proofs relating to both nonlinear continuous and discrete stability theory and is therefore of complex nature. The developed control design models are thus meant as the foundation in the process of designing feedback controllers for digital displacement units.