MSc Graduation projects (45 EC)

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Industrial partner: Damen Shipyards Group
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Starting date: ASAP, subject to negotiations, but no later than April 2014

Feasibility Study of a Hybrid Electric Ship using DC Microgrid Technology

The department of Electrical Energy Systems (EES) in collaboration with Damen Shipyards Group and a consortium of industrial partners are starting a Joint Industry Project (JIP) to investigate the technical and economic feasibility of an onboard DC microgrid for both civil and naval ship applications.

The hypothesis is that such a new design will exhibit better performance than existing AC microgrid designs, in terms of reducing the number of conversion steps to feed the large % of native DC loads, increasing the efficiency of variable speed generators and/or motors (related emission reduction) and stimulates modular ship design. In addition, simpler integration with battery storage systems is envisaged.

Case studies will be performed on two already in service ships (a civil and a naval ship) on which a conventional AC grid is installed. The case studies focus on re-engineering of the electricity grid into an onboard DC grid concept. Functional requirements for these case studies will be defined by Damen and related customers or ship owners.

Two complementary MSc thesis projects are described below.

Project 1 (EE, SET, SENSE or SELECT MSc student) Technical and economic evaluation of onboard DC microgrid for ship applications.

Goal: Technical and economic feasibility of a DC grid based on operating conditions
-- sizing of electrical equipment (power rating and nominal voltage) taking into account reliability and redundancy requirements.
-- comparing DC grid case study concepts to conventional AC topologies in terms of overall conversion efficiency, scalability/expansion possibilities, modularity etc.
-- modeling and simulation of components (generators, converters, DC grid, batteries, super-caps, motors, static loads) in cooperation with JIP partners
-- modeling and simulation of the integrated DC microgrid according case studie concepts
-- Figure out peak shaving topologies in which buffers and variable speed generators are applied related to case study concepts which results in possible fuel savings.

-- Economic evaluation AC vs. DC which is related to short term investment and long term benefits due to fuel savings.

Modeling environment: Matlab/Simulink or in consultation with JIP partners

Project 2 (EE MSc student preferably) Control and Protection of onboard DC microgrid for ship applications.

Goal: Testing the robustness of a given DC microgrid design under abnormal operating conditions
-- a basic DC microgrid topology is assumed which is in accordance with DC grid case study concepts
-- develop or use existing models of components (generators, converters, DC grid, batteries, super-caps, motors, static loads) capable of reproducing dynamic phenomena in the frequency range of electromagnetic transients
-- develop an integrated DC microgrid simulation model including appropriate protection and control philosophy, also paying attention to fault-ride through solutions for the power electronics converters
-- simulate a number of critical failure modes, e.g. loss of components and faults in the AC or DC parts of the grid, and verify that the protection and control mechanisms are able to isolate the fault (selectivity) and (partly) resume normal operation
-- identify vulnerabilities in the design that may lead to partial or total loss of power to mission-critical functions which is essential for well-substantiated DC grid feasibility analysis of both civil and naval ships.-- optional: EMC analysis of the DC grid concept

Modeling environment: Matlab/Simulink, PSCAD, DigSilent Power Factory or in consultation with JIP partners