



DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Modeling and Power Quality Assessment in Shipboard Microgrids

Location: Pontoppidanstræde 111, auditorium

Time: Friday 7 December at 13.00

PhD defendant: Wenzhao Liu

Supervisor: Professor Josep Guerrero

Moderator: Sanjay K. Chaudhary

Opponents: Associate Professor Tamas Kerekes, Dept. of Energy Technology, Aalborg University (Chairman)
Julio Barros, University of Cantabria, Spain
Janusz Mindykowski, Gdynia Maritime University, Poland

All are welcome. The defence will be in English.



Abstract:

With the growing development of power electronics technology onboard, ship power systems can be seen as shipboard microgrids (SMGs), which shows specific features such as higher torque-dense electric propulsion system, large-power pump motor loads, and smart power management and monitoring devices. In this background, power quality issues onboard are of a significant concern caused by the wide application of variable frequency drives such as bow thruster drives, large power pumps loads, fans and propellers.

This project provides PQ assessment methods for SMGs under both unbalanced and harmonic AC bus voltage conditions. The impact of voltage unbalance combined with harmonics on the SMG behaviors are analyzed, some models and controllable experimental research are proposed and carried out in a real ship under sea-going conditions. The experiments are presented considering real non-linear bow thruster motor and high power ballast pump loads at steady and transient conditions. In addition, the transient impact of voltage dips has been carefully analyzed based on maritime standards methods. The research work proposed modeling methods based on the critical ship system parameters, which can be easily applied for PQ assessment onboard. Moreover, voltage dips caused by pump loads can lead to generator unbalanced fundamental current and harmonic current surges, which have been carefully analyzed.

On the other hand, an interesting evaluation method for voltage dips is proposed to estimate the expected severity of voltage dips and generator current transient surges due to the onboard motor start-ups under real ship sea-going conditions. The PQ assessment model is based on the Riemann-summation-principle evaluation method. The methods are validated by measurement data gathered from the practical SMG during the ballast pump motor starts, which can provide engineers with necessary information of the actual magnitude/depth of voltage dips and transient peak value of generator current. In addition, the maximum allowable capacities of power motors can be estimated, which is beneficial to determine proper motor starter designs and improve the PQ in real SMGs.

It is worth noting that power quality issues are still challenging for SMGs systemically analysis. However, the proposed methods are able to obtain simplified models allowing quick analysis and accurate PQ assessment in practical ships, especially under unbalanced and harmonic voltage conditions.