The e-DRIVE 2018 Newsletter (May 2018)

e-Drive: All Electrical Drive Train for Marine Energy Converters

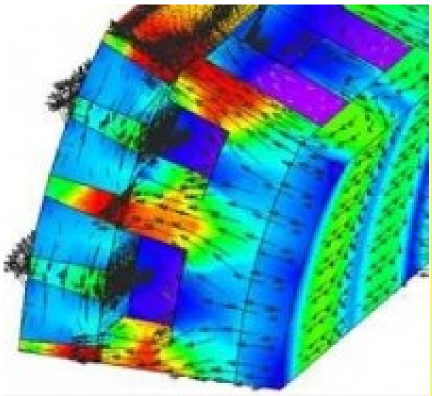
Project Summary

The e-Drive project will develop an innovative, integrated electrical power take off system with non-mechanical speed enhancement for use in marine energy converters.

The goals of the e-Drive project have been defined following extensive discussion with industrial and research partners and are aligned with the needs of the developing marine energy sector. e-Drive will develop an integrated electrical power take off (PTO) system with non-mechanical speed enhancement and integrated, reliable, flexible power electronics. This PTO will provide adaptive control over a wide range of operating regimes, taking into account nominal and extreme load conditions. This will require the development of novel, integrated, low speed generators with speed enhancement, power converter topologies and associated control to replace more conventional hydraulic systems.

The e-Drive project is a collaboration between the Institute for Energy Systems at the University of Edinburgh (UoE) and Newcastle University's Electrical Power Group (NCL), with the collaboration of other Project Partners who are noted leaders in the marine energy and power conversion sectors. Funding is provided by the Engineering and Physical Sciences Research Council (EPSRC) under the SuperGen Marine 2015 programme.

The e-Drive project is composed of seven Work Packages (WPs) and will last 3 years/36months from 1st April 2016 – 31st March 2019. Below the achievements to date in years 1 and 2 of the project and those planned activities for the final year, year 3, of the project are summarised.



WP1: Speed Enhancement

Achievements to date The particular topologies to be investigated further have been identified and include a novel form of magnetically geared linear to rotary conversion. Advanced 2D and 3D models have been developed - a parametric finite element model of one of the conventional pole modulating magnetic gears has been created and an analytical model of the same type is also being developed in order to facilitate rapid simulation and identification of the main parameters of interest.

Activities for Year 3 In order to address the low frequency issue associated with wave energy while avoiding traditional mechanical gears, magnetic gears have been investigated for application across a variety of wave energy devices. 2D and 3D magnetic gear modelling and optimisation tools have been developed and applied to case. These tools are now being used for advanced dynamic testing in conjunction with the WP3 hydrodynamic modelling software and in a case study designing a linear power take off system that combines the magnetic gear with the consequent pole linear Vernier hybrid permanent magnet machine being developed at Newcastle University.

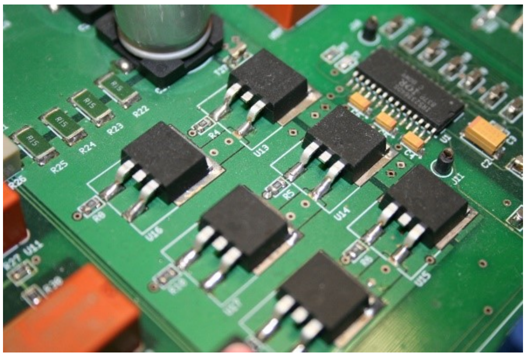
THE UNIVERSITY of EDINBURGH

Newcastle University

WP2: Integrated Power Converter

Achievements to date Thermal cycling is an issue for power converters. Low frequency pulsating power flow is expected in waves. Multiple bi-directional inverters are connected in series for multiphase machines. This approach is used in wind and automotive, but not for bi-directional power flow. Using this approach, smaller, cheap devices could be achieved, as well as an improved reliability, modularity and higher flexibility. Interactions have been evaluated and optimised (converter architecture, machine power factor, power flow, cost, complexity, overall drive train efficiency, thermal fatigue, switching device utilisation and wave energy converter control).

Activities for Year 3



To date, work has been done on the power converter to focus on CSI (Current Source Inverter) technology, as it is more novel than VSI (Voltage Source Inverter). The last will be kept as a backup in case CSI does not look promising. Applications of CSI to two different generator technologies will be done.

WP3: System Modelling and Control

Achievements to date A suite of free and open-source tools for wave-to-wire modelling have been developed through the EDRIVE project. Tools include a fork of the WEC-Sim code for wave energy converter simulation. Our version does not require Simulink or Simscape Multibody, or even Matlab as it also targets Octave, and is optimised for batch processing and optimisation. An advanced pre and post-processor for MBDyn, the multibody dynamics engine which replaces Simscape Multibody is also available and a nice Matlab/Octave preprocessor for Nemoh (the open source equivalent of WAMIT) has just been developed. The model also supports co-simulation with multi-rate models to achieve high levels of fidelity in loosely coupled parts of the system with very different time constants without resulting in huge simulation times.

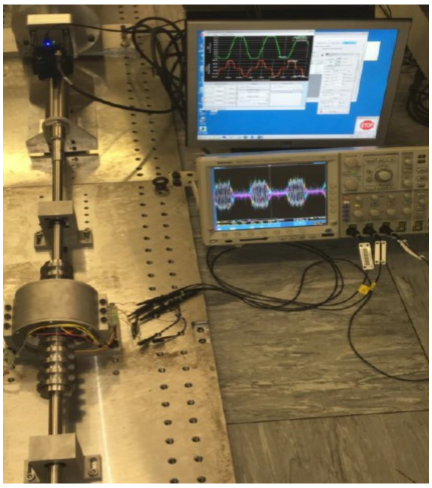
Activities for Year 3 The software toolkit will be released in mid-2018 along with documentation and guidance. A tutorial will be held at ICOE conference in Cherbourg in June 2018.

WP4: Design for survivability

Activities for Year 3 During extreme events there is a lack of generation in order to guarantee mechanical and structural survivability. In this WP, an estimation of stresses, fatigue, and displacements in generator structural design are needed. A matrix of extreme load severity vs. percentage reduction in structural life will be developed. Moreover, design guidelines and recommendations will be given.

This WP will commence once further information has been gathered from industrial partners.

WP5: Experimental demonstration



Achievements to date: NCL has built and tested two small-scale cylindrical prototypes of Vernier hybrid machines (VHM), while other three flat double-sided VHMs are being under construction and will be tested within this year. The two cylindrical machines are made from solid Soft Magnetic Composites (SMCs) blocks and successfully tested in the lab. They provide compactness, mass reduction and better performance compared to the flat counterpart. One of the flat machines, called Consequent Pole VHM offers a significant saving in magnet mass by 50%. The tapered ferromagnetic poles have been adopted in this design to further reduce the leakage flux and improve the machine performance. The second flat design is a new configuration of the design described above which incorporates V-shape magnets and consequent poles, in which the focusing flux caused by V-shape magnets can increase the airgap flux density and hence the power factor. The final flat design has Halback arrays with split teeth on its stator, while it has a segmented translator with less active mass. The machine structure can also tackle the problem of the leakage flux shown in the baseline VHMs leading to an improvement of the power factor.

WP6: Design Case Studies

Achievements to date

Activities for Year 3 Design studies for each industrial partner device will be developed. A full design report including a fully integrated electro-mechanical generator and power converter (WPs 1, 2 and 4) will be produced. Dynamic simulation results of each device under different sea states (WP5) will be developed.

WP7: Industrial Engagement & Impact Management

Achievements to date The project has presented at several conferences and industry events including the European Wave and Tidal Energy Conference 2017 and the Renewable Power Generation Conference 2017 in Wuhan, China. The project website is fully functional and has regular news updates and a partner database has been developed.

Activities for Year 3 The industrial advisory board has helped direct the project and the end of year 2 board meeting will take place at the ICOE conference in June 2018 in Cherbourg. This will help the project to remain aligned with industry needs. In addition, the results of the project will be presented at several conferences and events including:

1. International Conference on Ocean Energy in June, Nick Baker presenting and Richard Crozier delivering a tutorial to release the WP3 software outputs.
2. Asian Wave and Tidal Energy Conference, 2018
3. Renewable Power Generation, 2018 which will also give the research team further opportunities for industrial engagement.

For the latest project details please refer to http://www.edrive.eng.ed.ac.uk/ or contact edrive@ed.ac.uk.