

Mobile & Marine Robotics Research
Centre



PhD Research Project:

Ground Station Design and Optimization for Airborne Wind Energy

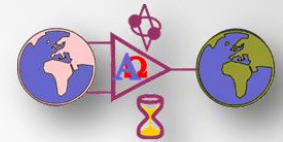
Supervisor: Dr. Daniel Toal

Student: Mahdi Ebrahimi Salari



University of Limerick

Mobile and Marine Robotic Research Centre (MMRRC)

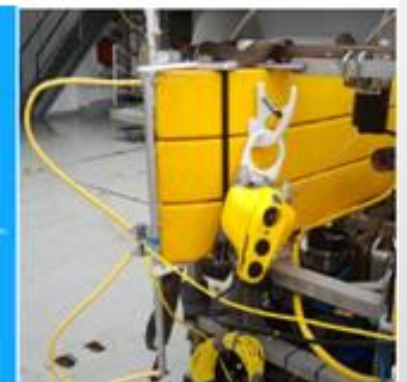
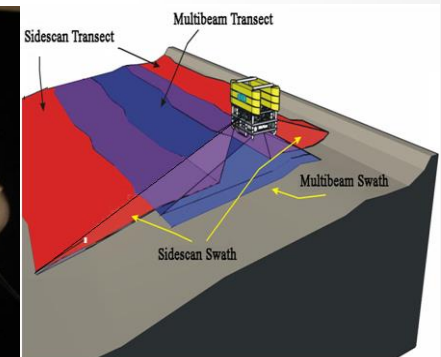


Mobile & Marine Robotics Research
Centre

- Established in 2000 by Dr. Daniel Toal
- Development of marine robotics within the island of Ireland.

➤ Technologies:

- ❖ Smart ROV Systems
- ❖ ROV Latis
- ❖ Ocean Rings
- ❖ Precision Navigation Autopilots
- ❖ Sonar Technology
- ❖ Airborne Wind Energy
- ❖ Etc.

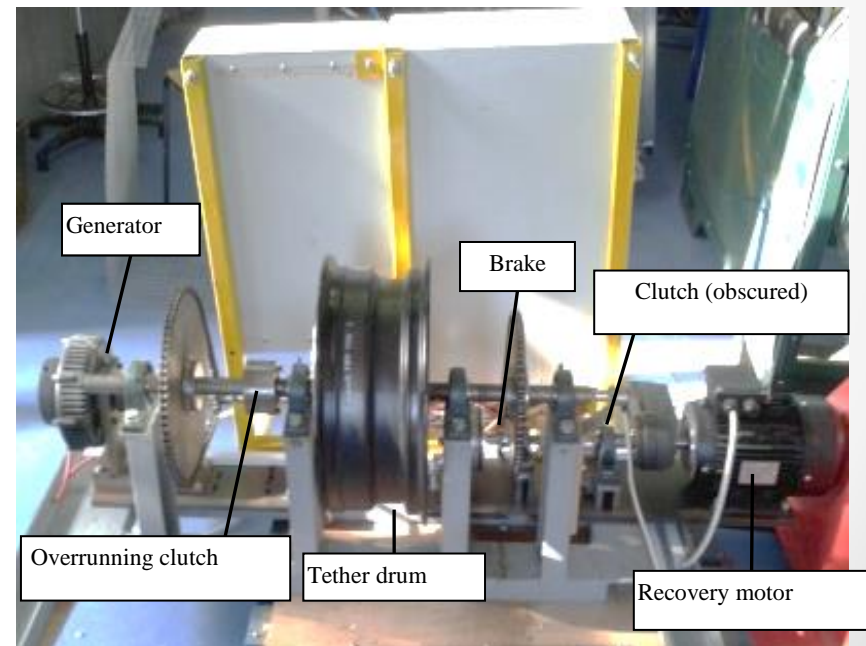
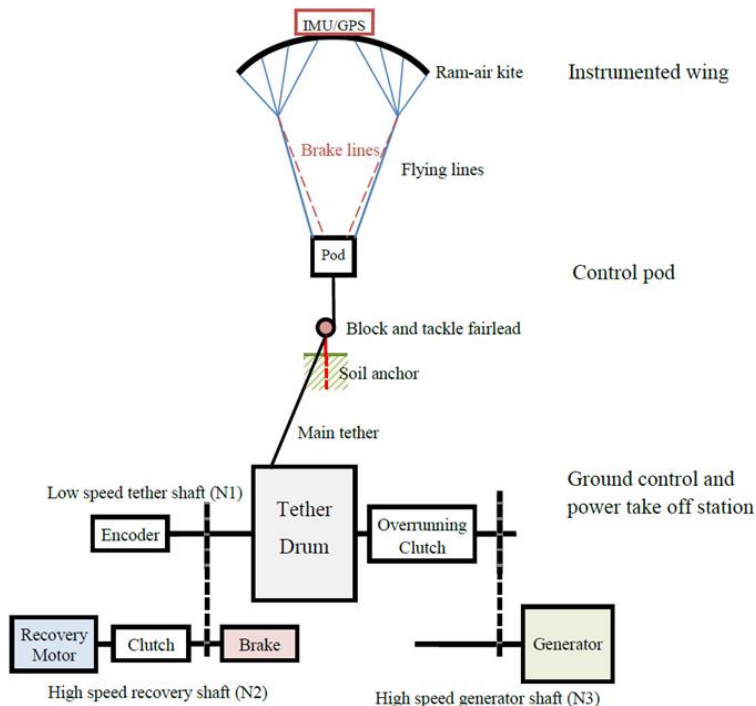


Airborne wind energy at MMRRC

Joseph Coleman

Distributed Control System and Novel Power Take Off Method for Pumping-Mode Airborne Wind Energy

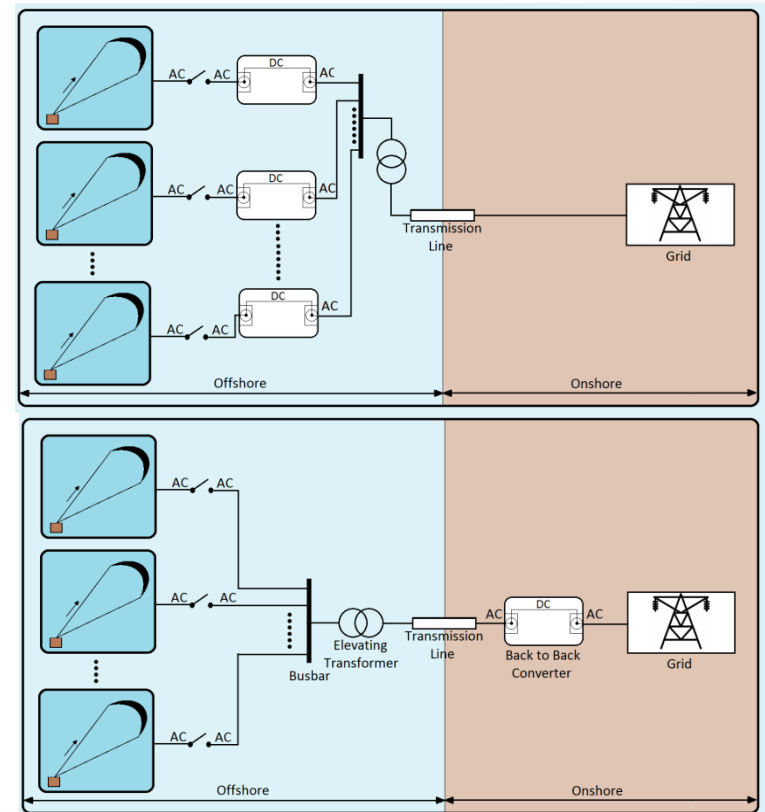
PhD thesis, University of Limerick, Oct.2014



Project Description

Project objective: Integration of AWE farms in compliance with transmission and distribution system operator grid codes

- ❖ Conventional approach to interconnect offshore generators:
 - High expenses of Installation, Repair and maintenance for off-shore systems
- ❖ Direct interconnection technique
 - More economical
 - More reliable



Research Methodology

Laboratory Rig

- ❖ Three 1.5 kW permanent magnet synchronous generators which are coupled with three phase induction motors as prime movers
- ❖ Three variable frequency drives for controlling the speed of prime movers (3ph induction motors)
- ❖ NI Compact RIO along with NI LabVIEW as data acquisition and control system

Research Methodology

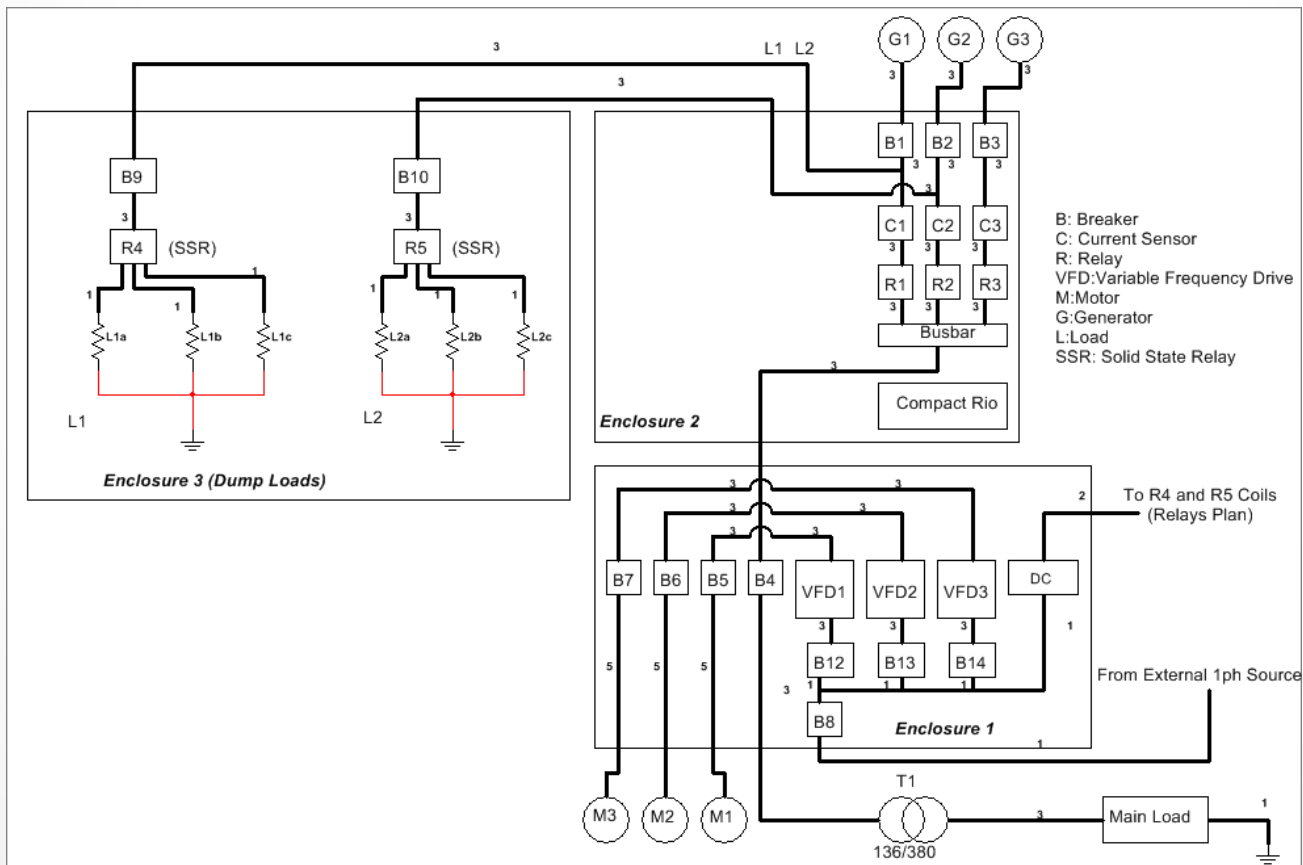
Laboratory Rig

Applications:

- ❖ Modelling of non-reversing pumping mode AWE
- ❖ Investigate different synchronization and interconnection strategies
- ❖ Modelling of small scale AWE farms and investigate interaction between AWE units and grid

Research Methodology

Laboratory Rig



Research Methodology

Laboratory Rig



Research Methodology

Laboratory Rig



Coupled Motor-Generator



Variable Frequency Drives (VFDs)



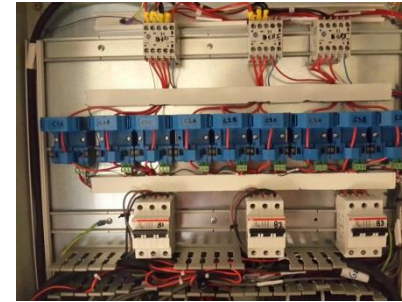
NI CompactRIO



Computer & Network Switch



Main Load



Current Sensors

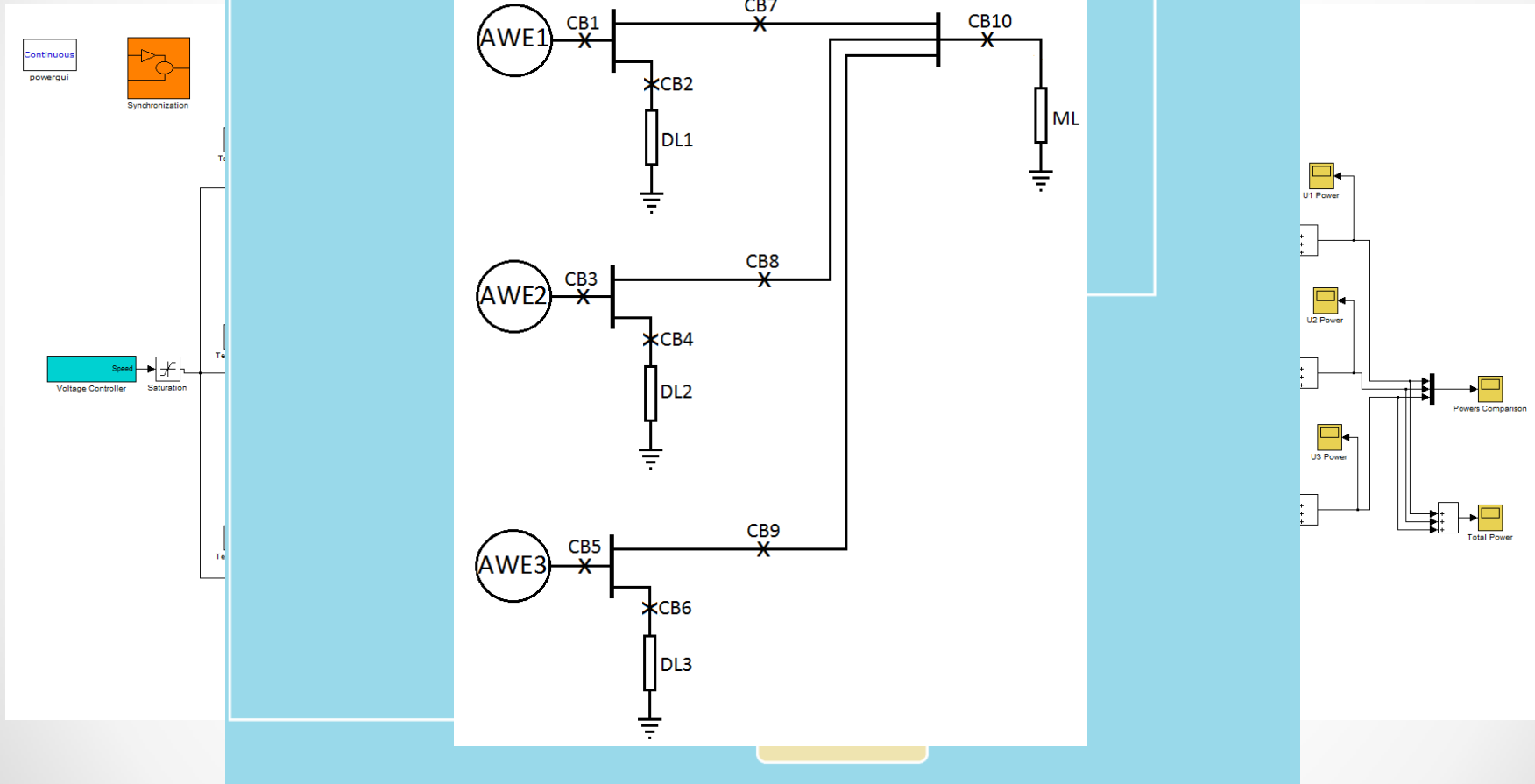


Dump Loads

Research Methodology

Simulation

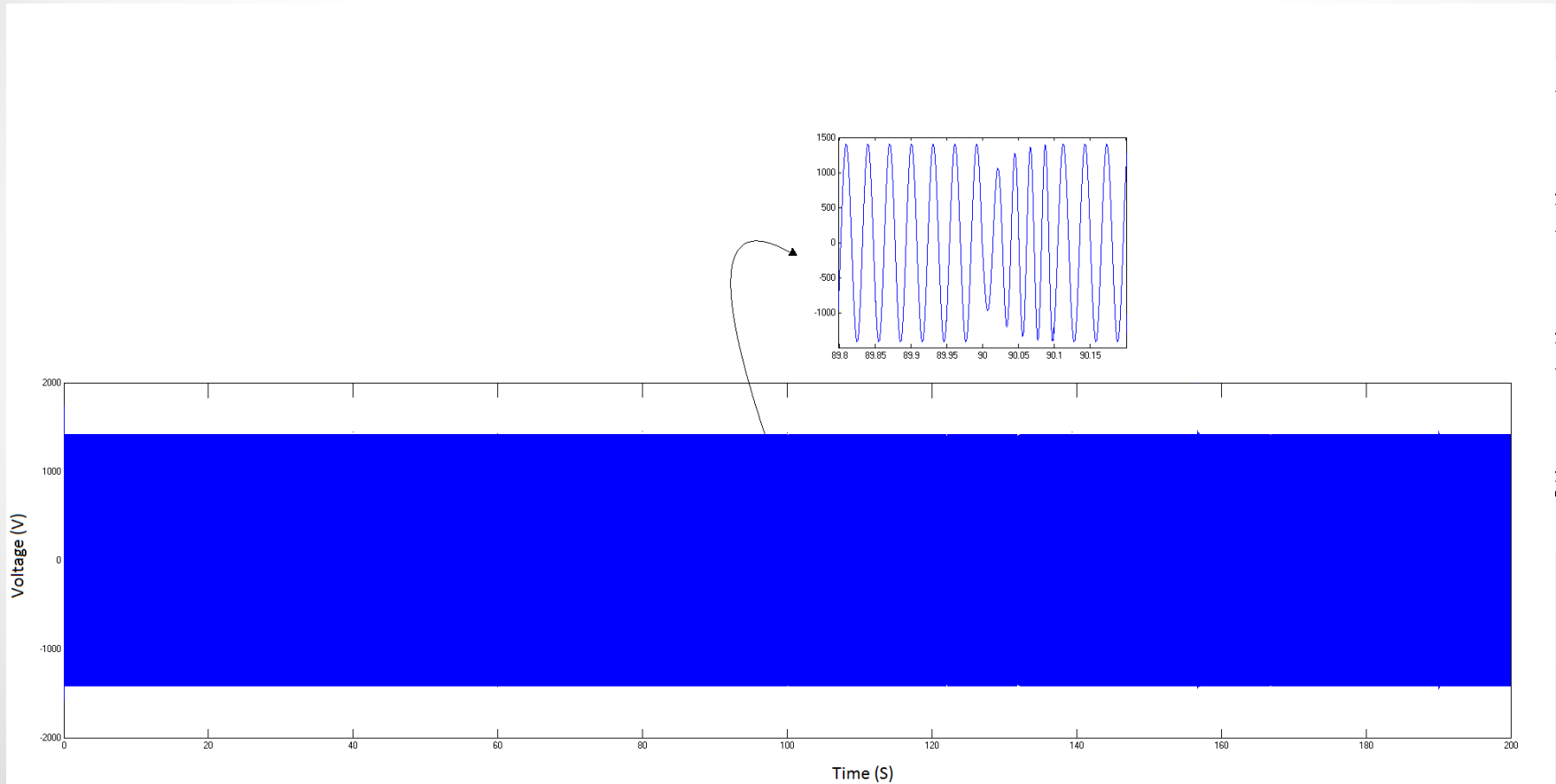
- ❖ Control approaches to increase system efficiency
- ❖ AWE farms in large scale
- ❖ Grid interconnection of AWE farms
- ❖ Transmission systems



Simulation of small AWE farm to investigate direct interconnection

Research Methodology

Simulation



Generated voltage

Publications

- ❖ Mahdi Ebrahimi Salari, Joseph Coleman, Gerard Dooly, Daniel Toal, “Direct Interconnection of Offshore Airborne Wind Energy Systems”, MTS/IEEE Oceans’15 conference, Washington , DC , October 19- 22, 2015
- ❖ Mahdi Ebrahimi Salari, Joseph Coleman, Daniel Toal, “Airborne Wind Energy- A Review”, 3rd ENEFM2015 Conference , Oludeniz, Turkey, October 19-23, 2015

Plan for the future

❖ Laboratory rig:

- Modelling of small AWE farms with the aim of exploring the electromechanical dynamics of interconnected AWE systems
- Testing different interconnection methods to find a reliable and economical approach.

❖ Simulation models:

- Modelling of offshore AWE farms in coordination with laboratory rig.
- Modelling of airborne wind energy farms in large scales
- The development of ground station will be investigated to improve system performance.

❖ Secondments:

- May and June 2017, 2 months at Skysails to get familiar with industrial airborne AWE systems.
- March and April 2018 , 2 month at ALU-FR will take place to work on the modelling and control system of rigid wing AWE systems for interfacing of airborne system to the multiple AWE generator rig.

Conclusions

- **Direct interconnection** would be an appropriate technique to reduce the repair and maintenance cost of offshore AWEs
- **Laboratory rig and computer simulations** are used to design and test different synchronization and control approaches for the interconnection of off-shore AWEs

• ***Thank you for listening***