Laboratoire d'accueil	L@bISEN – Yncréa Ouest Brest (France)
Intitulé :	**Power management in multi-source electrical propulsion system for ships**
Equipe d'encadrement (En France) :	**Directeur de thèse** : Yassine AMIRAT Yassine.amirat@isen-ouest.yncrea.fr **Encadrant :** Zhibin ZHOU Zhibin.zhou@isen-ouest.yncrea.fr
Equipe d'encadrement (Au Liban) :	**Directeur de thèse** : Clovis FRANCIS cfrancis@ul.edu.lb **Encadrant :** Maher El Rafei maher.elrafei@ul.edu.lb

Research Topic

Electrical propulsion systems have generated increasing interests in ships due to their low emissions and high maneuverability. For the future electric grid on ships, it can be considered as a multi-source micro-grid with distributed power supply sources (fuel-cells, wind turbines, photovoltaic panels) and different storage systems (batteries, flywheels, and supercapacitors). Efficient load sharing and power management via advance power converter control are required to insure good robustness and stability.

Indeed, unlike conventional power plants, in which synchronous generators are dominant, distributed generation systems with DC bus connection could have either very little or no rotating mass (the main source of inertia) or no damping property. The impact of low inertia and the absence of damping effect have a negative consequence on the dynamic performance and stability. To solve this problem, it is necessary to use storage devices and power converters to realize virtual synchronous generators (VSG). A key aspect is to handle the topology changes caused by the integration of VSGs as new control devices and to exploit the flexibility of the VSGs. An essential prerequisite for the development of VSGs lies in the development of algorithms for controlling the active and reactive power flows, emulating the inertia and estimating/stabilizing the frequency.

Another point is to improve the fuel-cell power conversion chain. The advantage of fuel-cell is the high energy density compared to the batteries but the recharge of fuel-cell needs hydrogen sources. For future boat system, it will be possible to electrolyze the seawater for obtaining hydrogen needed for fuel cells and the extra power for the electrolyzing system should be provided by renewable sources.

In this thesis project, we will focus on the development of intelligent and robust algorithms to keep the balance between the powers demanded/supplied on the boat and maintain high stability of voltages/frequency with extended autonomy.

References:

1. M. N. Boukoberine, Z. Zhou, M. Benbouzid and T. Donateo, "A Frequency Separation Rule-based Power Management Strategy for a Hybrid Fuel Cell-Powered Drone," *IECON 2020 The 46th Annual Conference of the IEEE Industrial Electronics Society*, 2020, pp. 4975-4980, doi: 10.1109/IECON43393.2020.9255118.

2. Z. Zhou, M. B. Camara and B. Dakyo, "Coordinated Power Control of Variable-Speed Diesel Generators and Lithium-Battery on a Hybrid Electric Boat," in *IEEE Transactions on Vehicular Technology*, vol. 66, no. 7, pp. 5775-5784, July 2017, doi: 10.1109/TVT.2016.2638878.
3. Hezzi, Abir, Seifeddine Ben Elghali, Yemna Bensalem, Zhibin Zhou, Mohamed Benbouzid, and Mohamed N. Abdelkrim. 2020. "ADRC-Based Robust and Resilient Control of a 5-Phase PMSM Driven Electric Vehicle" *Machines* 8, no. 2: 17. https://doi.org/10.3390/machines8020017
4. A. Belila, Y. Amirat, M. Benbouzid, E. M. Berkouk, G. Yao, Virtual synchronous generators for voltage synchronization of a hybrid PV-diesel power system, International Journal of Electrical Power Energy Systems, volume 117, 2020, https://doi.org/10.1016/j.ijepes.2019.105677, 2020.