PhD Student Proposal: Projet-ANR-20-CE05-0034

DICIT: Development and Integration of static DC / DC Converters for the Interconnection of high voltage DC Transmission grids

The DICIT project is funded by the French national research agency (ANR)

Background and context:

The massive exploitation and utilization of fossil-fuel energy had led to increased greenhouse gas emissions and other environmental damages with the consequences we are currently experiencing. With the worldwide consciousness of environmental priorities, several protocols have been signed and implemented to limit their impacts. One of the most important trend is the reduction in use of traditional fossil-fuel energies by their replacement with renewable sources known as cleaned energy (such as solar and wind power). In France and Europe, high-end renewable energy sources are more based wind turbine on isolated sites in the sea, generally offshore. This source is more important as the turbines are installed far from the seashore. The location of these sites requires submarine cables. The use of conventional AC transmission over long distances is not feasible and DC grids are thus justified as it has technical and economic advantages compared to AC. One major challenge *for the electrical engineering community* was to ensure a reliable and efficient interfacing system between the existing AC power system and the DC one. *S*ince its first publication in 2003 *[1],* the Multilevel Modu*lar Converter (MMC) technology* has achieved a high degree of maturity for high voltage applications. Actual examples can be found internationally such as TRANSBAY, INELFE, Zhoushan Multi-terminal DC *Interconnection et nNan'ao [2-3]* and many others. Definitely, the increased reliability of the powerflow transmission passes through the insuring the reliability of the DC grid. Such as the AC power system during the previous century, the reliability of a DC transmission system can be improved by interconnecting DC links together. Considering this fact, the concept of a meshed DC grid has emerged over the past ten years to ensure a better continuity of service, to reinforce the interconnections between different areas of Europe and several continents as introduced by the "SuperGrid" concept.

Grid interconnections of existing links are not straightforward as different voltage levels are nowadays used due to a progressive investment and design of the DC grid, non- industrial standardization between projects and also the permanent technology evolution.for example. It is thus necessary to introduce static DC/DC converters to ensure the interfacing of these different DC grids. However, the high voltage level of these HVDC grids exclude the use of conventional DC / DC converter topologies. The main suitable DC / DC converter topologies proposed for this application are built on the Multilevel Modular Converter (MMC) principles.

Preliminary studies have been done, both by the project partners [3-4] and other international research groups [5]. The operating principles of some proposed DC/DC converters topologies are now known but need to be deeper analysed to improve the transient behaviour or efficiency while other promising topologies merit to be totally studied. Moreover, no extensive work has been done on the integration and control of this type of converter in a meshed DC grid.

Project objectives and main scientific challenge:

The objectives of the DICIT PhD thesis are divided into 2 main axes:

1: The first axis of the study will focus on the further development of the preliminary studies carried out on DC / DC converters. Some converters associated with their control having a high level of reliability, a high efficiency and being tolerant to DC grid faults (short circuit) will be studied and their performances will be compared to the other in terms of losses, efficiency, transient and in case of default behavior.

2: The main PhD proposal topic will focus on the integration into HVDC grid environment of two preselected converters by the first axis study. This part will focus on the management of power flows and the stability of a mesh DC grid integrating a DC / DC converter.
The contribution in the development of a demonstrator is envisaged in support to a post-doctoral member on the project.

Skills:

The PhD-position's main objective is to qualify for work in research positions.

- the candidate must have a master's level in electrical engineering or equivalent
- The candidate must have solid skills in power electronics, control, analysis and power systems.
- The candidate must have the ability to work into a team and well organize himself.
- Good communication and writing skills in English are mandator
- A past experience related to research activities will be appreciated.

We offer:

- exciting and stimulating tasks in a strong international academic environment (France and UK).
- an open and inclusive work environment with dedicated colleagues and a high-level hardware equipment.
- Localization: Arts et Metiers Sciences et Technologies - Lille, L2EP - 8, Boulevard Louis XIV - 59000 LILLE.
- Duration: 3 years
- Supervisors: Gruson François (L2EP), Merlin Michael (Edinburgh), Vermeersch Pierre (L2EP).
- Salary: €1,640 net per month.
- This salary can be increased by the possibility to provide practical teaching in electrical engineering

The application must include:

- CV, certificates and diplomas
- Academic works - published or unpublished - that you would like to be considered in the assessment
- 2 or 3 Recommendation letters with email address of two referees

Deadline application: 21 May 2021

References:

[1] A.Lesnicar and R. Marquardt, "An innovative modular multilevel converter topology suitable for a wide power range," IEEE Power Tech. Conf., Bologna, Italy, Jun. 2003

[2] https://en.wikipedia.org/wiki/List_of_HVDC_projects

[3] Yafang Li, "A DC-DC power converter study for High Voltage Direct Current (HVDC) grid: Model and control of the DC-DC Modular Multilevel Converter (M2DC)", Ph.D Thesis dissertation, supervised by Philippe Le Moigne, Lille, École Centrale de Lille, 2019.

[4] F. Gruson, Y. Li, P. Delarue, P. Le Moigne, F. Colas and X. Guillaud, "Full State Regulation of the Modular Multilevel DC converter (M2DC) achieving minimization of circulating currents," in IEEE Transactions on Power Delivery. doi: 10.1109/TPWRD.2019.2942527 A Tlemcani, F. Gruson, Y. Li, P. Delarue, P. Le Moigne, X. Guillaud, «Convertisseur DC/DC haute tension tolérant aux défauts DC », symposium de génie électrique SGE, 2018 july 3-5, Nancy, France, in French

[5] A. Schön and M. Bakran, "Comparison of modular multilevel converter based HV DC-DC-converters," 2016 18th European Conference on Power Electronics and Applications (EPE'16 ECCE Europe), Karlsruhe, 2016, pp. 1-10. doi: 10.1109/EPE.2016.7695259