Master Internship proposal

Fault characteristics in MVDC and hybrid AC-DC networks & Protection scheme design

Profile : students at the Master 2 level (Master 2, grandes écoles)
Duration : 5 to 6 months, Desired start date from April to May 2025
Salary : Statutory bonus, approximately 650€ per month depending on the number of working days
Workplace : CentraleSupélec – Laboratoire GeePs, 11 rue Joliot Curie, 91190 Gif-sur-Yvette, France
Languages: French and/or English

Context

Distribution networks are undergoing a rapid transformation, driven by the proliferation of DC loads, renewable energy integration, and energy storage. As these new network users increase, Medium-Voltage Direct Current (MVDC) networks have emerged as a promising solution. These networks offer simplified integration and reduced power electronic conversion costs and losses. MVDC networks are designed to interconnect with Medium-Voltage Alternating Current (MVAC) networks, enabling hybrid AC-DC structures that combine the benefits of both technologies. Within the framework of the operations of these hybrid networks, the management of the faults will lead to the definition of the protection scheme from an algorithmic point of view as well as from a material point of view.

Challenges

Fault detection in hybrid AC-DC networks can be particularly challenging due to the unique fault characteristics that may differ significantly from those observed in traditional MVAC networks. The specific fault behaviour will be heavily influenced by the network architecture, grounding systems, and the behaviour of individual components during faults. Moreover, power electronic converters can contribute to fault currents in various ways, depending on their structural design and control strategies. Consequently, conventional protection schemes relying solely on overcurrent relays may not be optimally suited for hybrid AC-DC networks.

Objectives and research program

Within the context of work package (WP) 3 of the DC-Architect project [1], the primary objective of this internship is to investigate fault characteristics in MVDC and hybrid AC-DC networks and design appropriate protection schemes.

The research will proceed in the following stages:

1. *Literature Review:* A comprehensive review of MVDC and hybrid AC-DC networks, including their protection strategies, will be conducted.
2. *Network Modelling***:** Benchmark network architectures, incorporating various power electronic converter structures, will be selected for modelling. Close collaboration with WP 1 of DC-Architect will ensure alignment. Fault transient simulations will be conducted to analyse fault characteristics.
3. *Protection Device Placement:* Depending on the fault characteristics and fault detection capabilities at different points of the hybrid network, the possible locations for the switching devices and protection relays will be determined.

4. *Protection Scheme Development:* Protection schemes will be developed and tested with offline simulations. Furthermore, hardware-in-the-loop (HIL) testing could be also employed for validation.

Desired skills

- Knowledge of electrical networks and fault analysis
- Experience in power system simulation, signal processing, data science would be an advantage.
- Good communication skills (both oral and written)

Contact : Please send a CV and a motivation letter to:
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References

[1] DC-Architect project description Co-designing future distribution grids based on their inverter-based components | ANR

[2] A. Mehdi, S.J Ul Hassan, Z. Haider, A. D. Arefaynie, J. Song, C. Kim, “A systematic review of fault characteristics and protection schemes in hybrid AC/DC networks: Challenges and future directions”, Energy Reports, Volume 12, 2024, Pages 120-142, ISSN 2352-4847,

[3] P. Dworakowski, J. D. Páez, W. Grieshaber, A. Bertinato, E. Lamard, “Protection of radial MVDC electric network based on DC circuit breaker and DC fuses”, International Journal of Electrical Power & Energy Systems, Volume 153, 2023, 109398, ISSN 0142-0615,

[4] P. Verrax, M. Kieffer, L. Milhiet and B. Raison, "Combined Data-Driven and Model-Driven Location of Lightning Strikes: Application to Meshed HVDC Grids," in *IEEE Transactions on Power Systems*, vol. 39, no. 2, pp. 3811-3824, March 2024

[5] P. Torwelle, A. Bertinato, B. Raison, T. D. Le, M. Petit, “Fault current calculation in MTDC grids considering MMC blocking”, Electric Power Systems Research, Volume 207, 2022, 107662, ISSN 0378-7796,