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Detailed Equivalent Model for an MMC-HVDC Connected Offshore Wind Farm under Normal and Fault Dynamic Performance Analysis

Authors: Mohammed abdedljalil Djehaf * 1 , youcef islam djillani kobibi 2 , Mohamed KHATIR

1 Faculté de Génie Electrique, Djillali Liabès University of Sidi Bel Abbès, Sidi Bel Abbès 22000, Algeria

2 Université Mustapha Stambouli Mascara, Mascara, 29000, Algeria

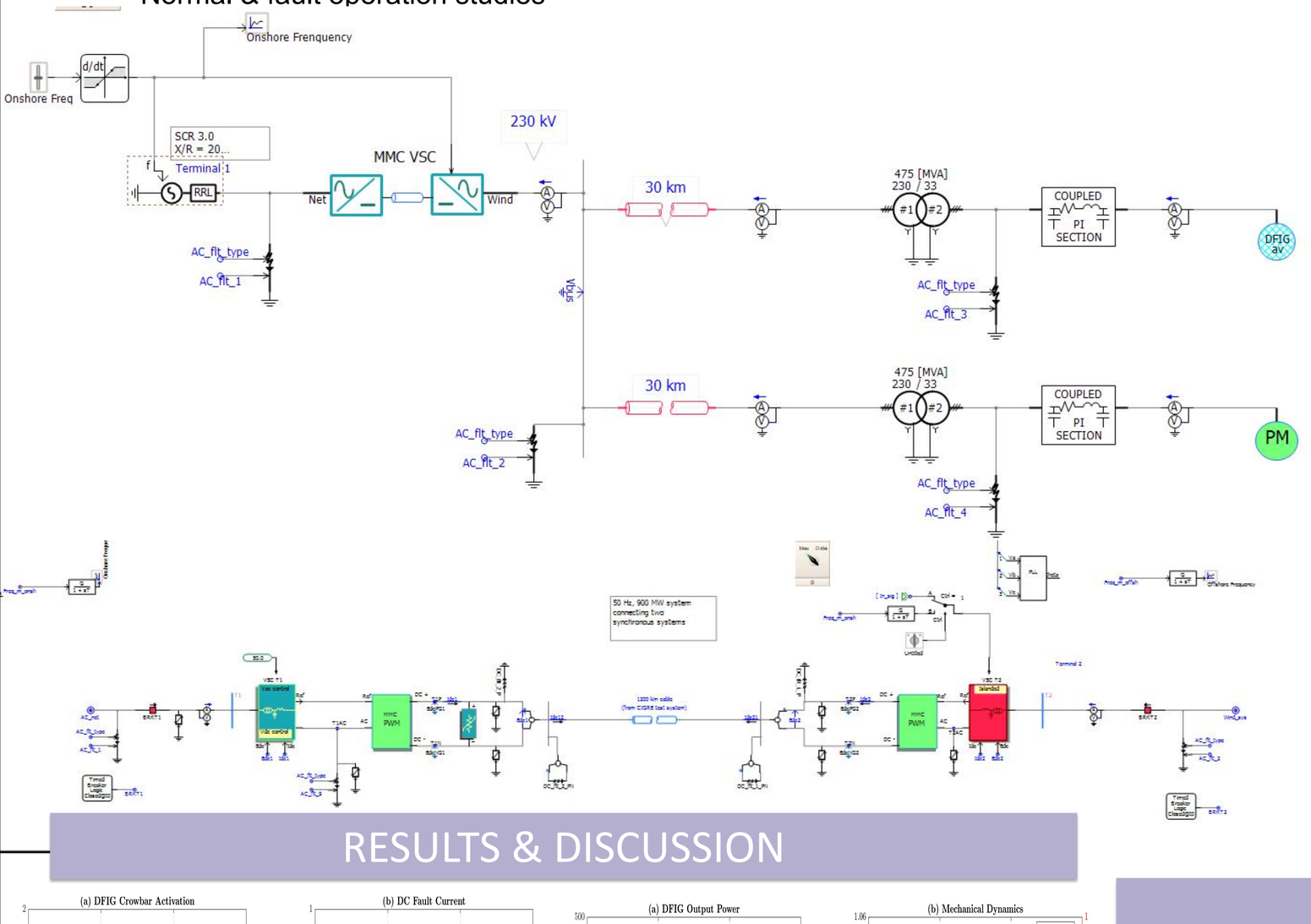
INTRODUCTION & AIM

Offshore wind energy requires efficient and reliable long-distance power transmission, for which MMC-based VSC-HVDC systems are the leading technology. However, detailed MMC models involve hundreds of submodules and switching devices, resulting in very high computational cost, especially for system-level and DC fault studies. While simplified models improve speed, they often lose accuracy during fast transients. **This work is motivated by the need for an MMC model that combines high accuracy with low computational burden.** A novel Thevenin-based equivalent modeling approach is therefore proposed to enable efficient and accurate simulation of offshore wind farm MMC-HVDC systems under both normal and fault conditions.

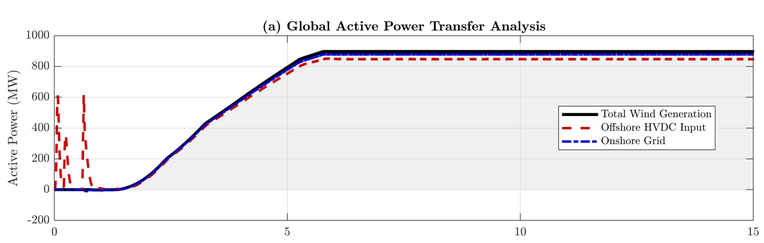
Objectives

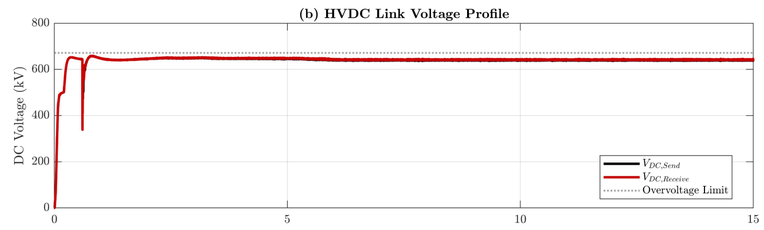
- Develop a Thevenin equivalent-based detailed MMC model
- Reduce the number of electrical nodes drastically
- Preserve:
  - Steady-state accuracy
  - Dynamic behaviour
  - Fault current representation

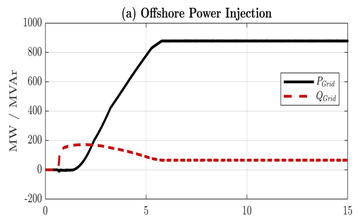
  Apply the model to:
  - Offshore wind farm connected via MMC-HVDC
  - Normal & fault operation studies

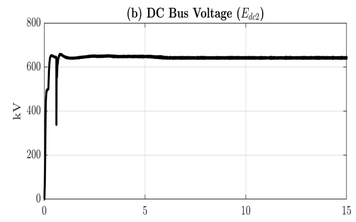


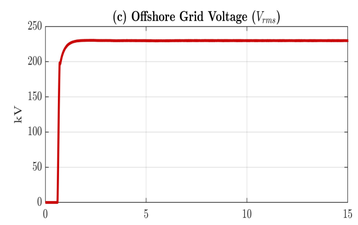
RESULTS & DISCUSSION

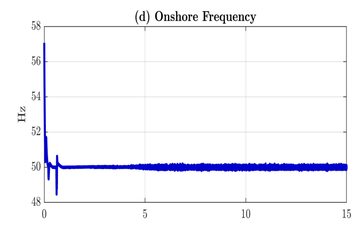


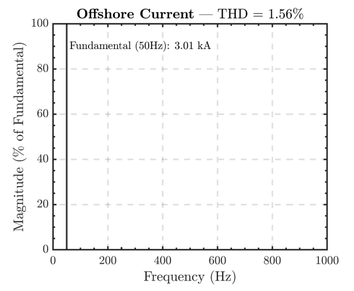


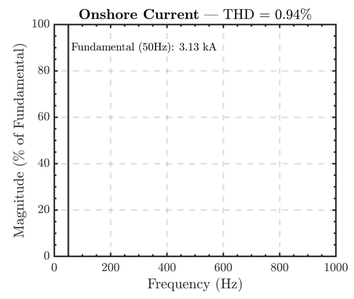


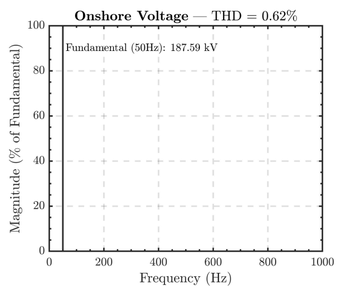


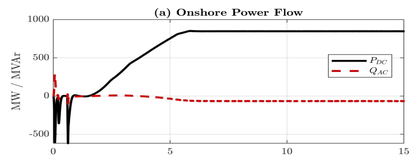


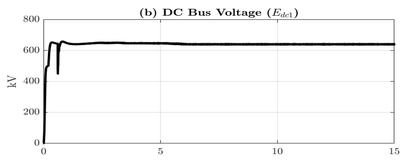


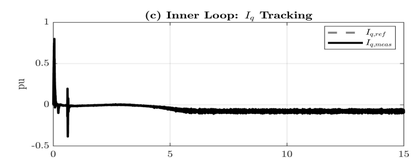


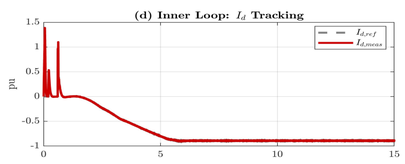


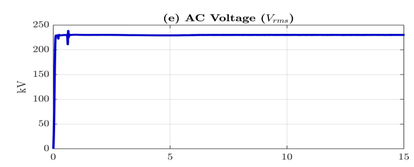


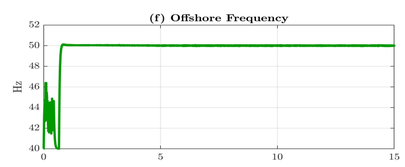


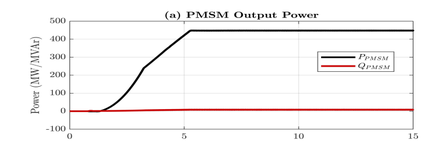


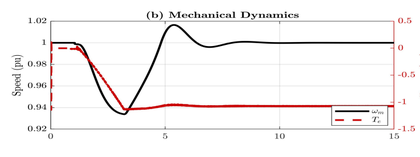


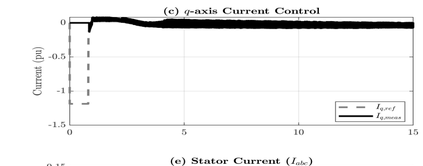


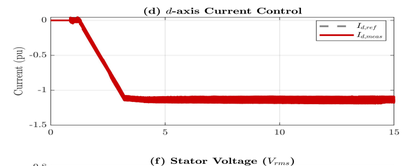


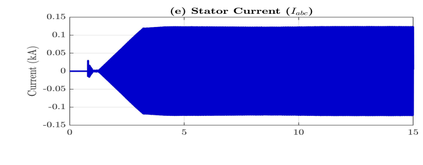


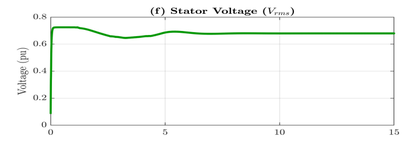


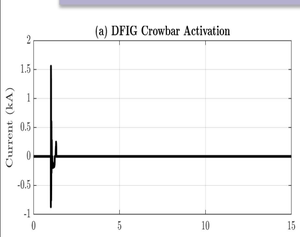


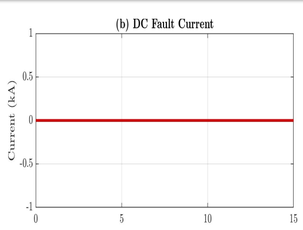


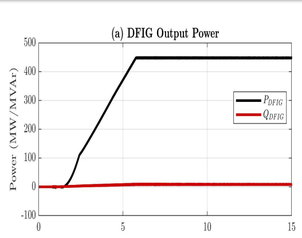


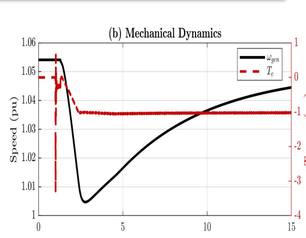


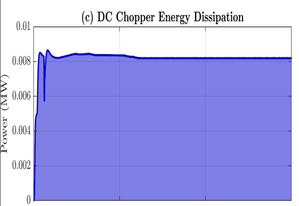


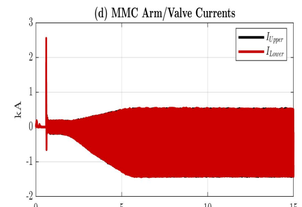


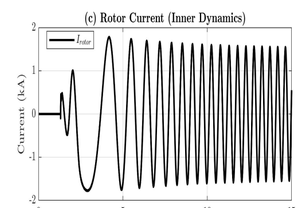


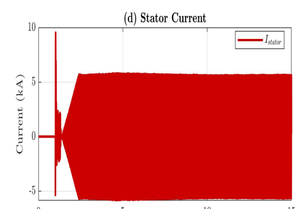


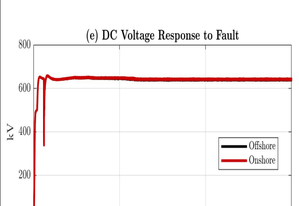


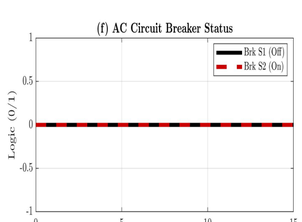


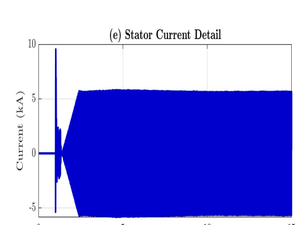


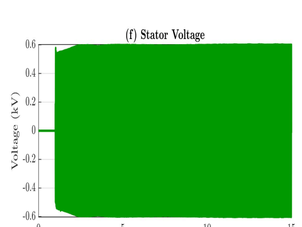












CONCLUSION

A novel Thevenin-based equivalent modeling approach for MMCs has been proposed to enable efficient simulation of offshore wind farm integration via VSC-HVDC systems. The developed model significantly reduces computational complexity while accurately preserving steady-state performance, dynamic behavior, and fault response characteristics. Simulation results under normal operation and various fault conditions confirm the effectiveness of the proposed method for large-scale system studies and DC fault analysis. This modeling approach provides a powerful and practical tool for advanced renewable energy integration and HVDC system research.

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