CIGRE JWG B4/C4.93 - Development of Grid Forming Converters for Secure and Reliable Operation of Future Electricity Systems

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Agenda

- Personal presentation
- Insights on the JWG B4/C4.93
- Technical developments

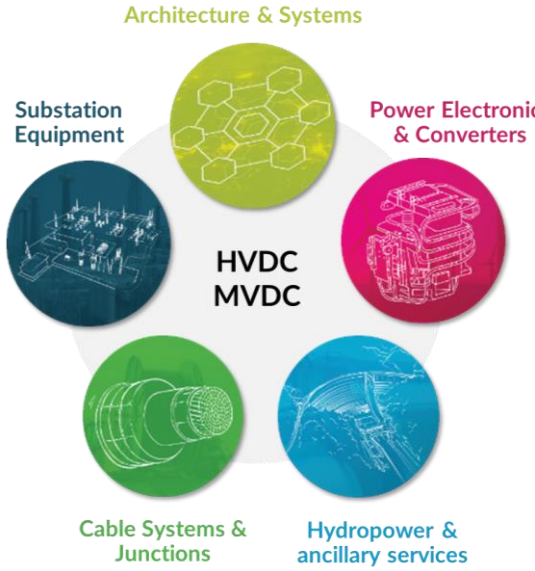
Personal presentation

- Research Engineer at SuperGrid Institute
  - ✓ **Domains of interest:**
    - HVDC systems supporting AC stability
    - Grids with high integration of power electronics
- Coordinator of the EU and UK funded **HVDC-**WISE project addressing:
  - ✓ **Resilience and reliability AC/DC grids via HVDC systems**
    - Dedicated control and protection
    - New HVDC supporting technologies
    - Adapted HVDC configuration design
- Member of CIGRE JWG B4/C4.93
  - ✓ **Technical secretary of Subgroup:** Provision of System Services from GFM converters
  - ✓ Participation in other subgroups for contribution and/or observation

SuperGrid Institute

SuperGrid Institute
Shaping power transmission

- Independent private R&D company (2014, 170p)
- European leader in HVDC & MVDC expertise
- Our technological solutions and services enable our clients and partners to accelerate the development of the power grids of the future
  - ✓ **HVDC transmission grids**
  - ✓ **Integrating massive renewable energies (OWF, PV, etc.)**
  - ✓ **MVDC systems**
  - ✓ **Storage & balancing**



Services & partnership (Consulting, testing & technologies)

egic, TRACTEBEL, Rte, Nexans, CHANTIERS DE L'ATLANTIQUE, ATHERM, le cnam entreprises, THALES, Schneider Electric, TenneT, EDF, CNR, IDB, ABB, TUNUR تونور, PSE, SAFRAN, ENERGINET, KOHLER SOREEL, ALSTOM, North Sea Wind Power Hub, Hitachi Energy

R&D collaboration

PROMOTioN PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS, XFLEX HYDRO, LISORE, SiCRET, RED ELECTRICA DE ESPAÑA, Grid 2030, LOLABAT LONG LASTING BATTERY, ARCHIVE, FastGrid

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Insights on the JWG B4/C4.93

Development of Grid Forming (GFM) Converters for Secure and Reliable Operation of Future Electricity Systems

- Contributing to a common understanding of GFM controls
- Contributing to a common definition of the functions/services provided by GFM converters
- Exploring advanced functionalities of GFM converters aiming the reliability of the power system
- Contributing to the definition of an approach to test and validate functions
- Learn from the vast experience of other members across the world
- Creating a connection and synergies between the different projects I am involved in

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Technical developments

Modular Multi-level Converter models with grid-forming controls (MMC-GFM)

Higher level of detail

RMS and dynamic phasor models

EMT models

Experimental muck-up

More simplified representation

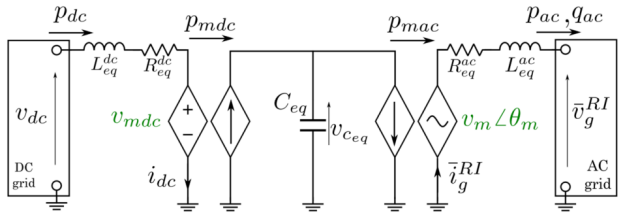
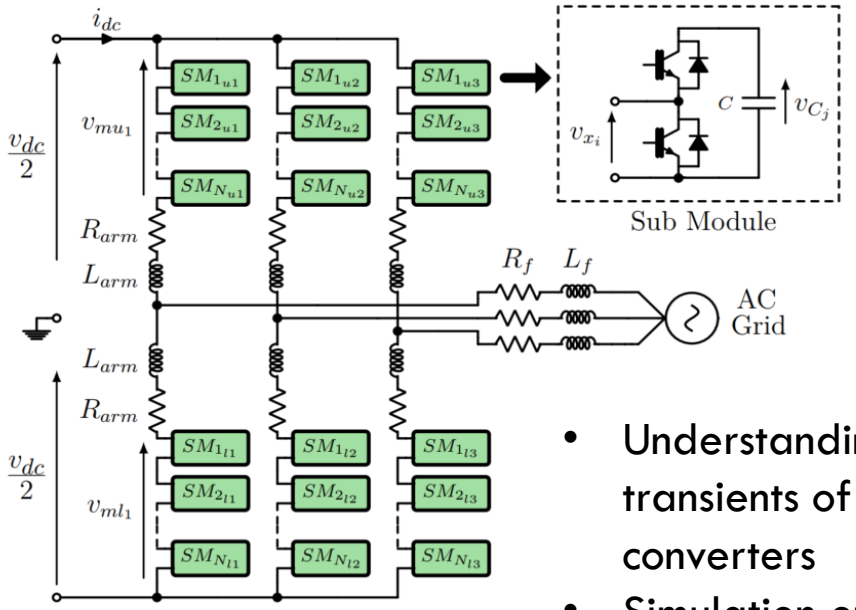


Fig. 1. MMC model under phasor assumptions



- Understanding the GFM converter dynamics of interest with simplified equations
- High level control design
- Simulation of large power systems with low computational efforts

- Understanding of fast transients of GFM converters
- Simulation of very detail models

- Hardware (controls and power devices) testing

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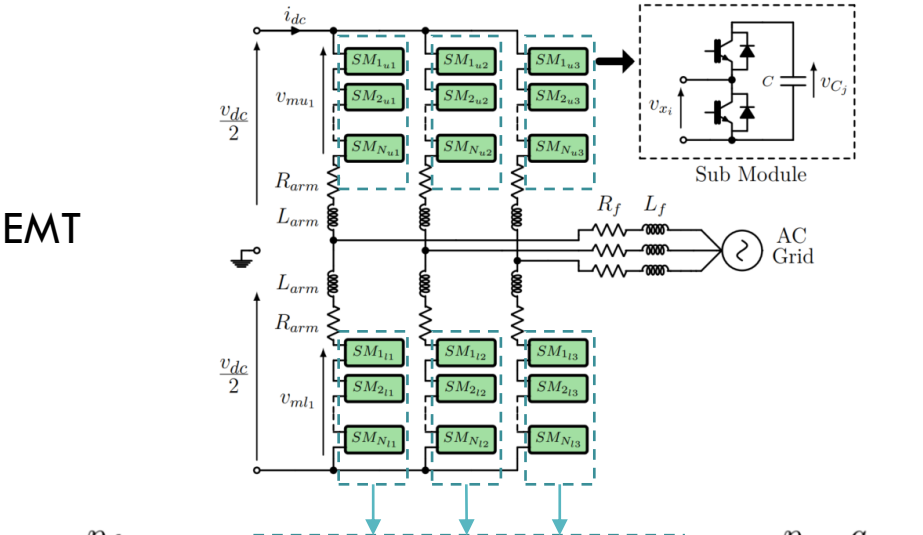
Technical developments

MMC-GFM dynamic phasor and RMS models

Model reduction

Full detailed EMT



Phasor

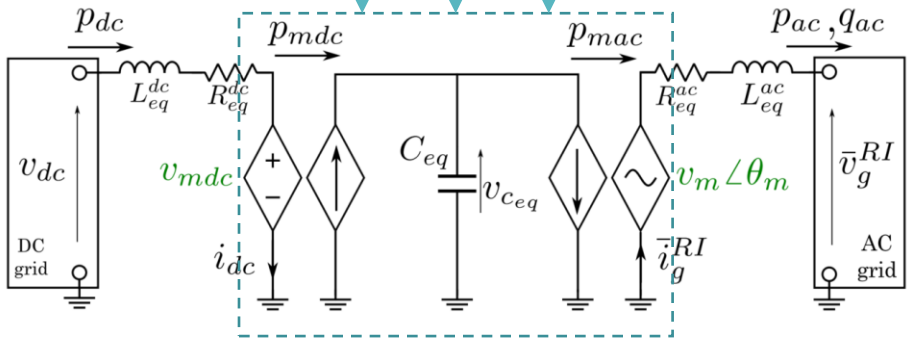
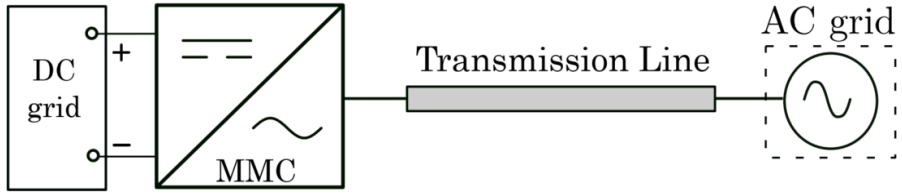


Fig. 1. MMC model under phasor assumptions

Validation: full detailed EMT vs Phasor



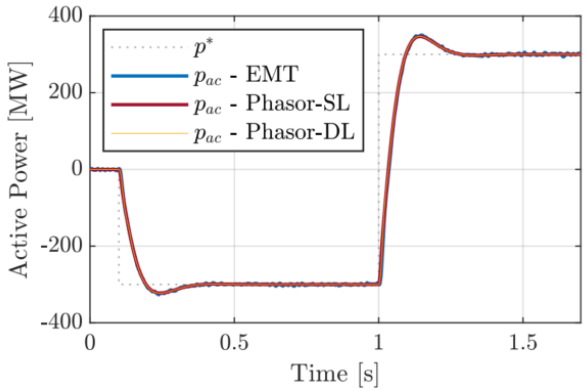


Fig. 6. P_{ac} mode - Active Power

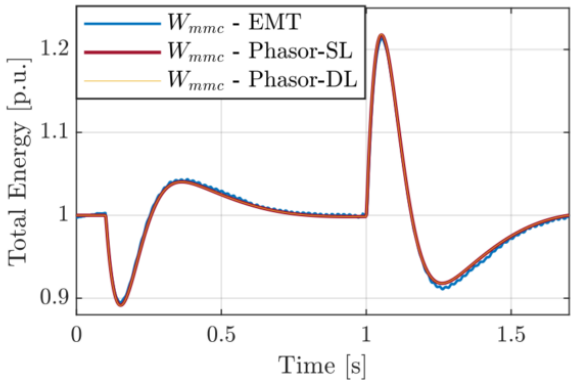


Fig. 7. P_{ac} mode - MMC internal energy

Freytes, Julian, et al. "Small-signal state-space modeling of an HVDC link with modular multilevel converters." *2016 IEEE 17th Workshop on Control and Modeling for Power Electronics (COMPEL)*. IEEE, 2016.

Technical developments

References to our group work

- Gonzalez–Torres, Juan Carlos, et al. "A simplified approach to model grid-forming controlled MMCs in power system stability studies." 2021 IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe). IEEE, 2021.

- Mourouvin, Rayane, et al. "Understanding the role of VSC control strategies in the limits of power electronics integration in AC grids using modal analysis." Electric Power Systems Research 192 (2021): 106930.

- Mourouvin, Rayane, et al. "An Overview on the Recent Advances of the Voltage Source Converter Control Modes in Terms of their Roles in Transmission Grid Ancillary Services." ENP Engineering Science Journal 2.2 (2022): 57-71.

- Mourouvin, Rayane. Converter control in a power system with high penetration of renewable energy. Diss. Université Grenoble Alpes, 2021.

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Thank you for your time !

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