



PROMOTiON

PROGRESS ON MESHED HVDC
OFFSHORE TRANSMISSION
NETWORKS



WP16 – MMC Test Bench Demonstrator

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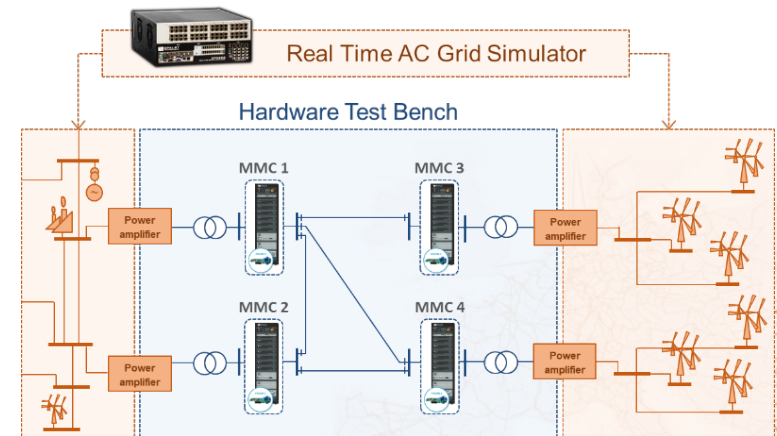
Overview and Objectives of WP16

Motivation:

- Meshed offshore DC systems lead to novel challenges for TSOs, manufacturers and grid planners
- Experience missing concerning
 - Multi-terminal operation
 - Interaction with the large AC transmission systems
 - Interaction with offshore WPPs

Work Package 16: Investigation regarding the operation and control of meshed HVDC system

- ✓ Power Hardware in the Loop (PHIL)
- ✓ Control Hardware in the Loop (CHIL)
- ✓ Real-Time Simulation (RTS)

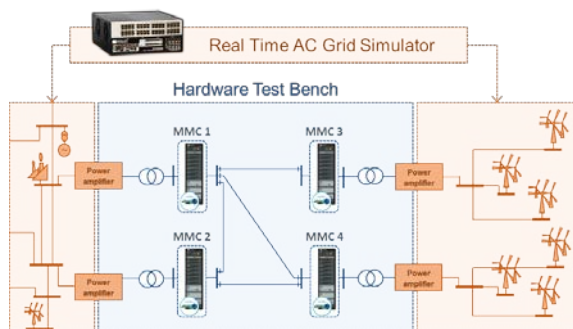


Objectives:

- **Demonstration** of applicability of developed controls and simulation models of PROMOTiON
- **Technical de-risking** for the deployment and continuous operation of meshed HVDC systems
- **Improvement** of certainty for road mapping process and standardization efforts

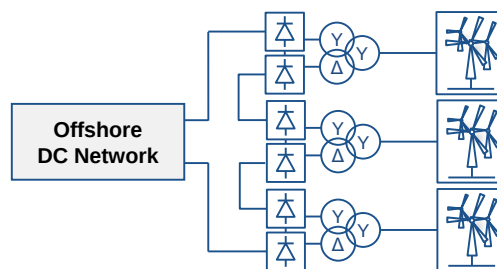
Overview and Objectives of WP16

MTDC Test Bench - PHiL



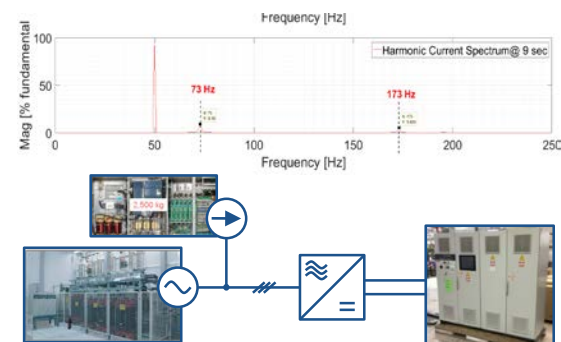
Analysis of the controllability of meshed DC offshore networks

Diode Rectifier Unit - CHiL



Increase the confidence in controllability of DRU connected wind farms

Harmonic Resonance Studies



Analysis of harmonic stability problems related to resonance phenomena

MTDC Test Bench - PHiL

State of knowledge:

Limited experience regarding the

- operation of MTDC systems
- interactions between MTDC systems, large AC systems and wind power plants

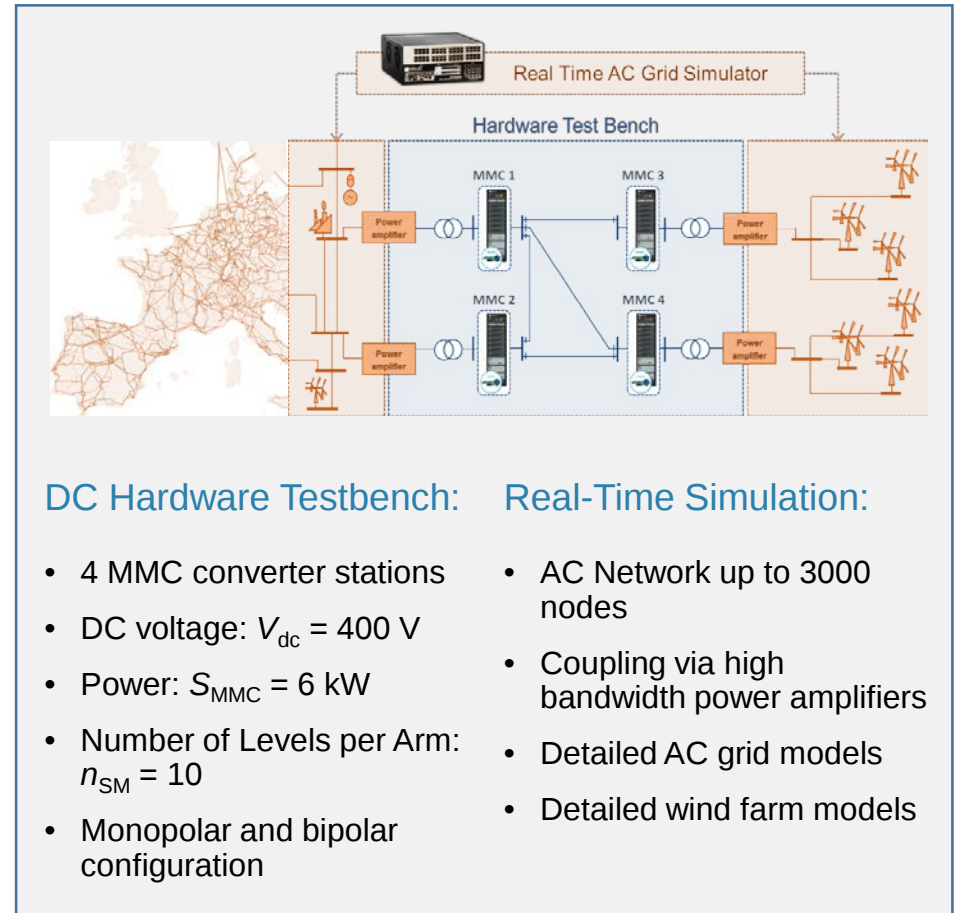
Objectives:

Investigation of the

- controllability and interoperability
- fault handling in meshed offshore grids
- AC grid support with meshed offshore grids

Expected outcome:

- Increase the confidence in the feasibility of MTDC operation
- Increase TRL of controls for MTDC systems



Diode Rectifier Unit - CHiL

State of knowledge:

- ✓ Islanded control concepts for DRU connected offshore wind farms
- Focus on aggregated or partially aggregated wind farm representation
- No experience between the interaction of protection relays and DRU connected WFs

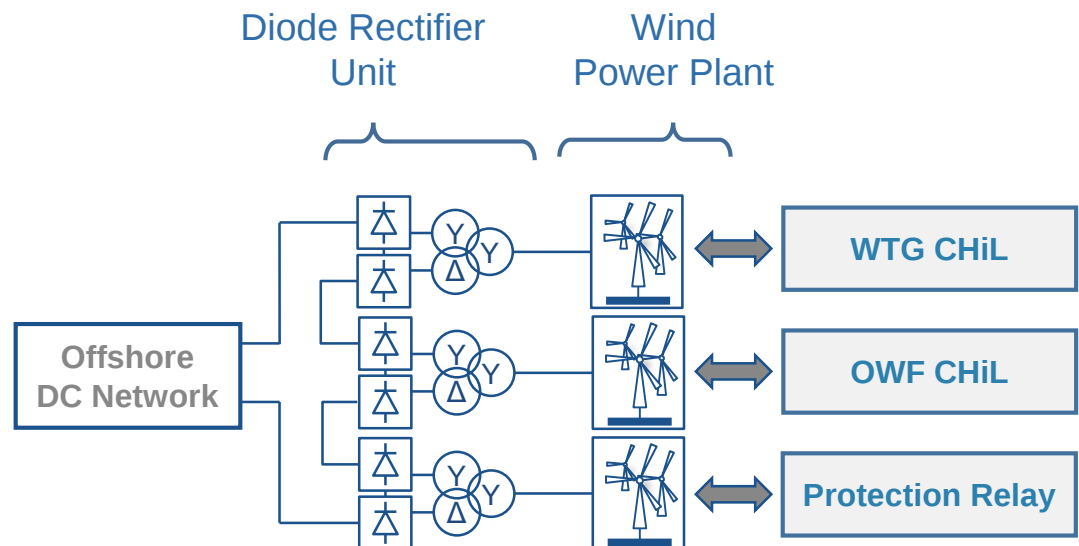
Objectives:

Demonstration of the operation of DRU-enabled wind turbine control systems

- in multi-terminal HVDC systems
- with actual wind turbine controls
- with commercial protection hardware

Expected outcome:

- Increase in confidence regarding the control of DRU connected wind farms
- Development of black and brown start operation for wind farms in islanded control



Harmonic Resonance Studies

State of knowledge:

- Increasing penetration of active components in transmission systems
- Harmonic oscillation between offshore wind turbine and HVDC converters

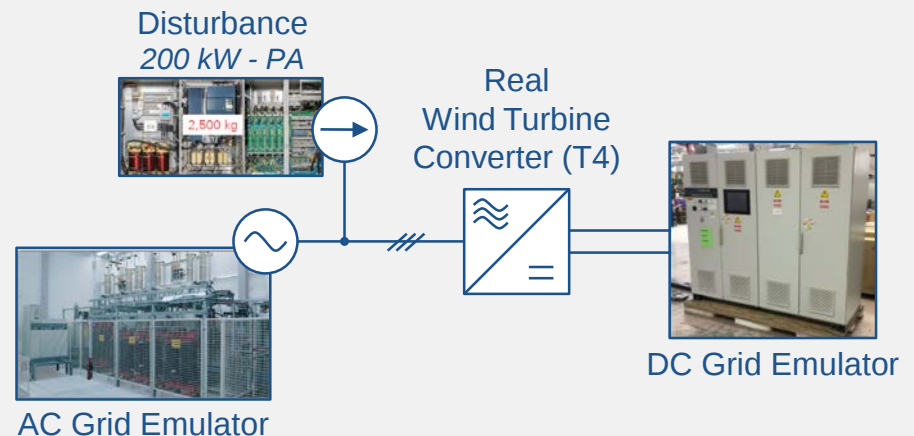
Objectives:

- Development of frequency dependent impedance models of wind turbines and HVDC converters
- Extraction of the frequency behaviour of a (real) wind turbine converter and of the MMC from the HVDC test bench
- Analysis of harmonic stability and potential interactions of active components and the AC grid

Expected outcome:

- Validated impedance models of wind turbine and HVDC converters
- Better understanding of harmonic stability, especially in offshore grids

Flexible Power Grid Laboratory (@ DNV GL)

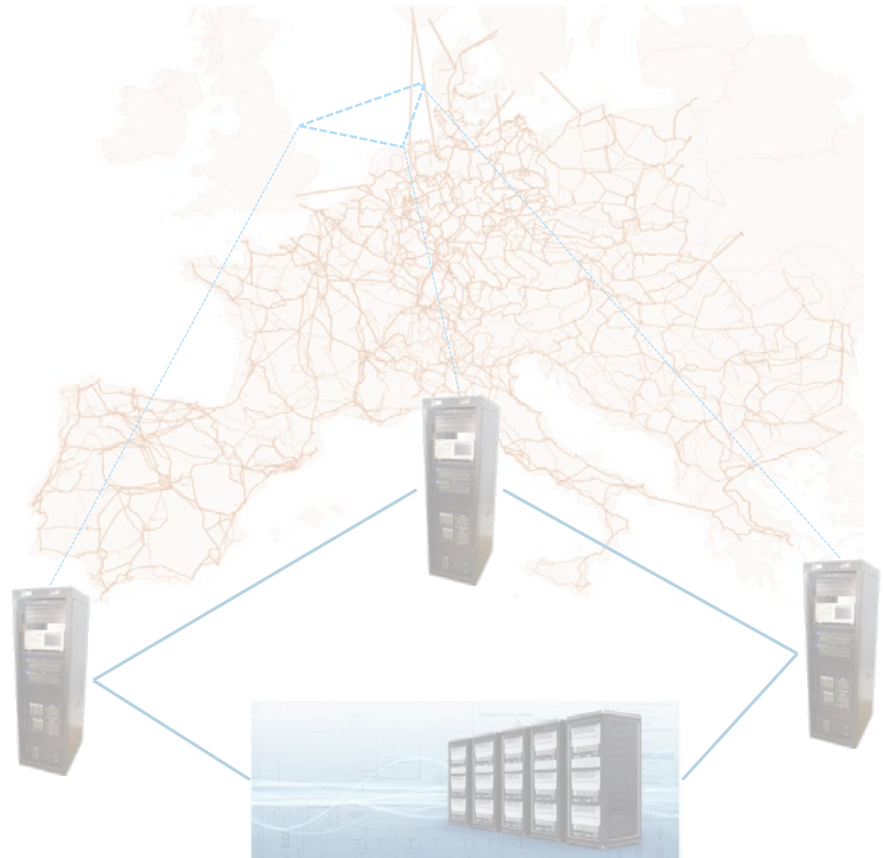


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APPENDIX

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