

WP16

MMC Test Bench Demonstrator – Introduction

Demonstration of Converter & Controller
Model Validation

15.08.2019 – Arnhem

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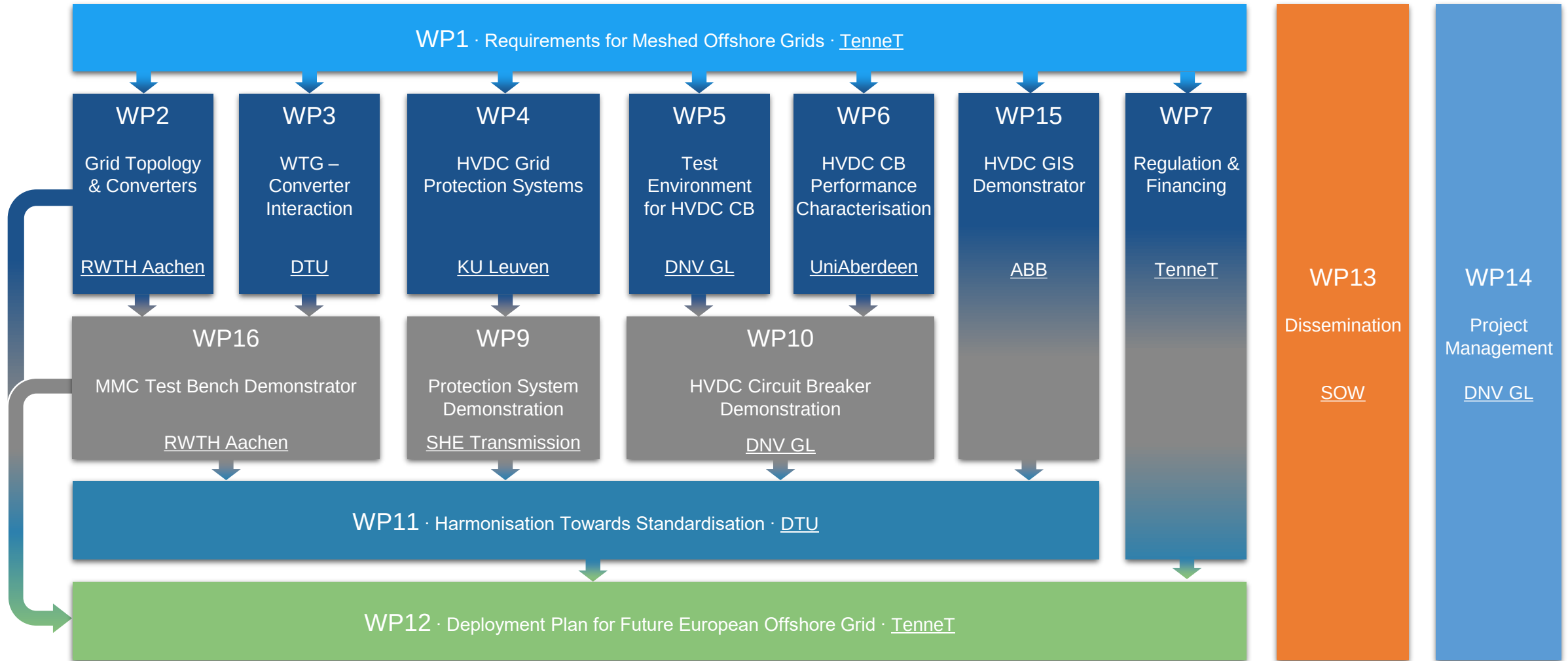


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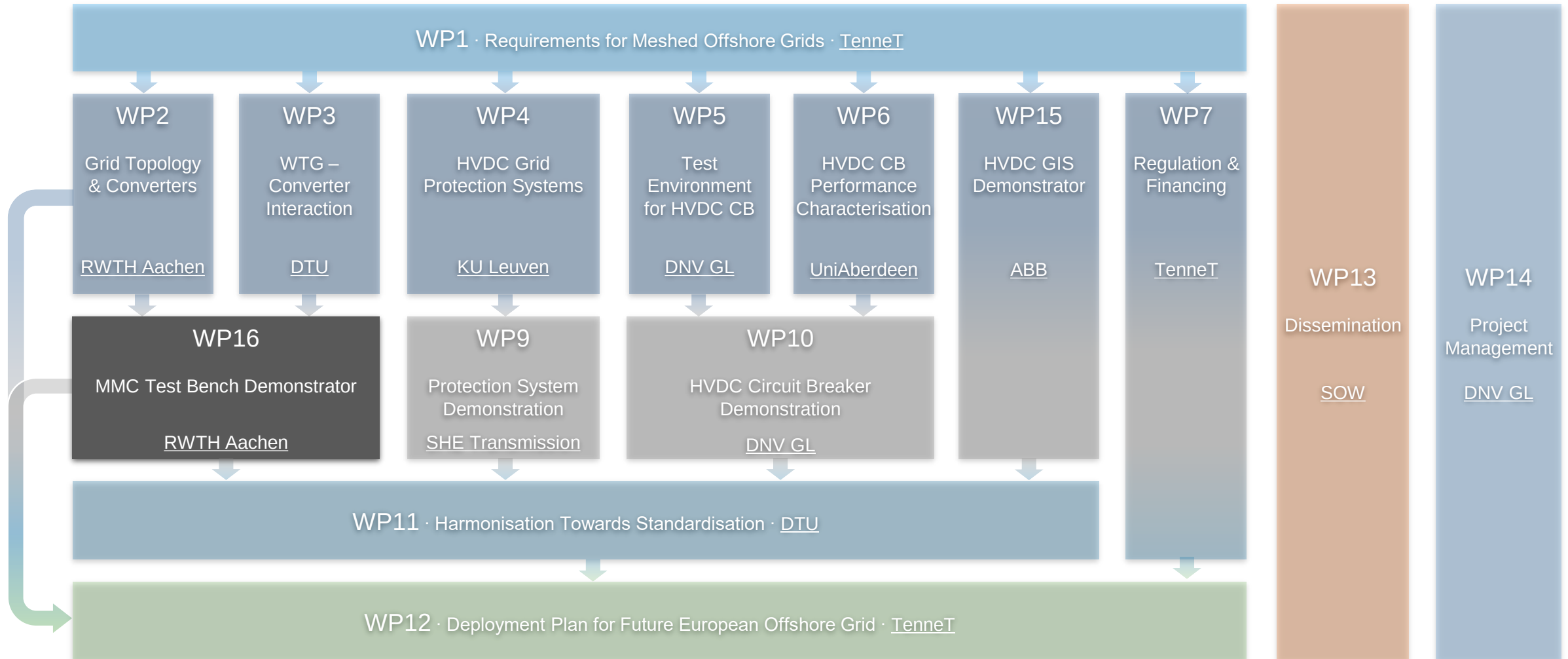
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Work Packages



Work Packages



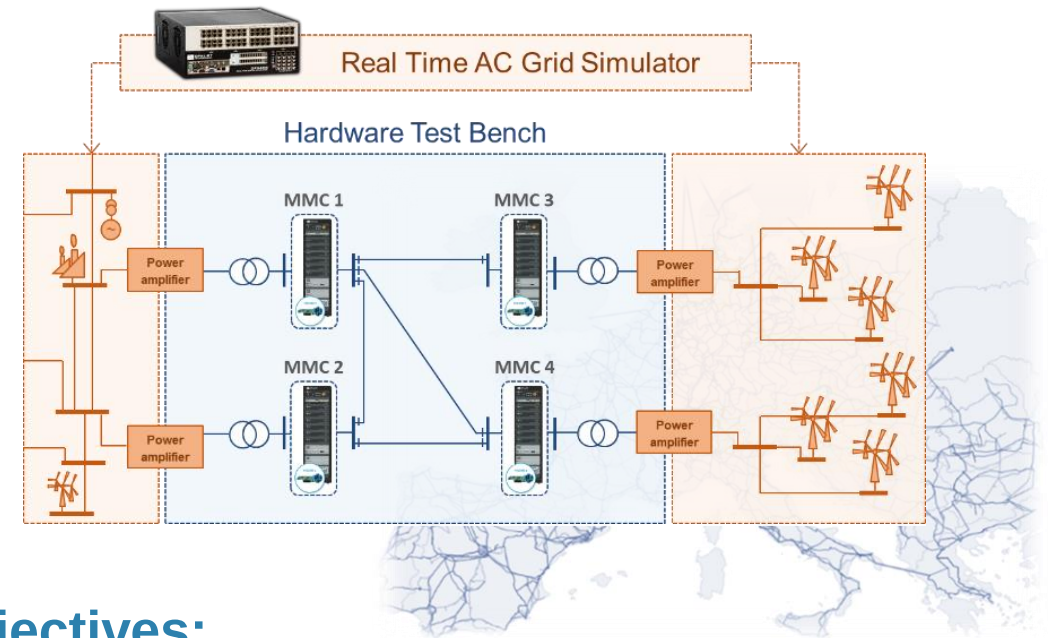
Overview and Objectives of WP16

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 wind farms

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)

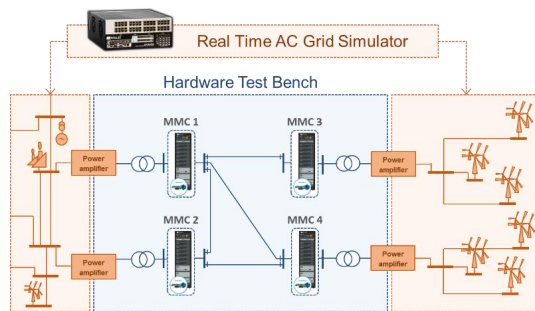


Objectives:

- Derive appropriate principles and policies to ensure interoperability between different components and technologies in meshed HVDC offshore grids
- Analysis of harmonic resonance phenomena in offshore grids (analysis of the freq. dependent impedance of MMC and WT-VSC)
- Demonstrate the operation of DRU

WP16 – Internal Structure

MTDC Test Bench - PHiL

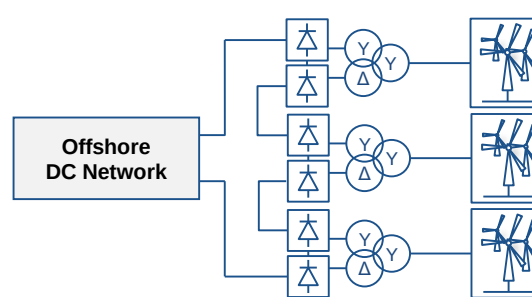


Test Cases

Demonstration of the controllability and interoperability offshore MTDC networks

- Grid & converter configurations
- Interaction MTDC network and OWP
- MTDC and OWP fault handling
- AC grid support with meshed offshore grids

DRU - WPP

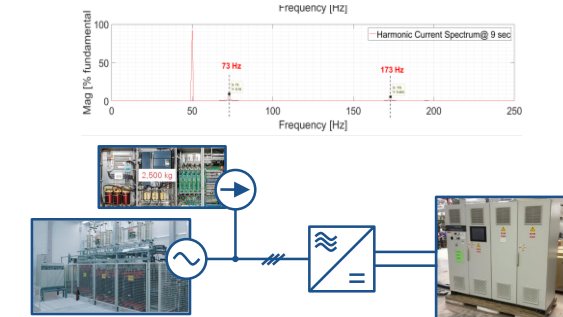


Test Cases

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
- black and brown start operation for wind farms in islanded control

Harmonic Resonance Studies



Test Cases

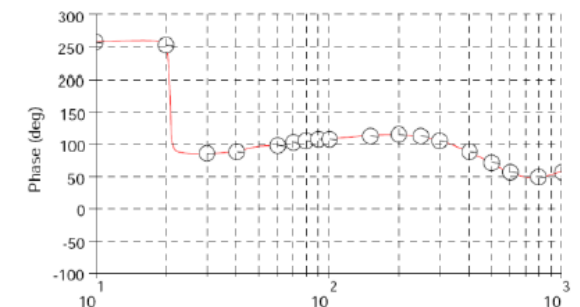
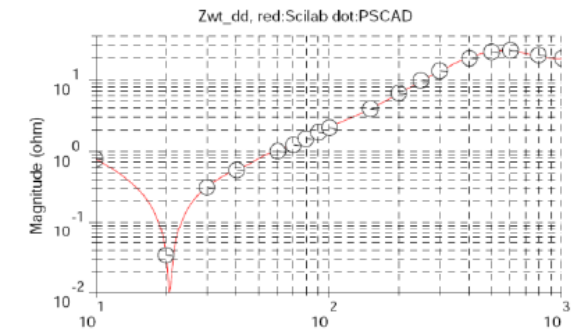
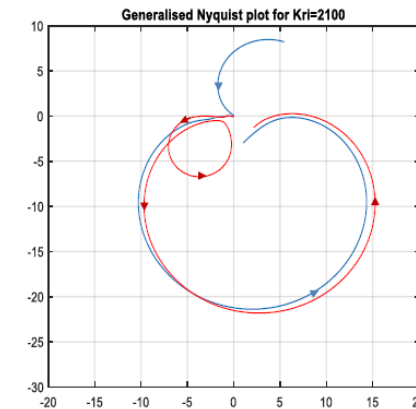
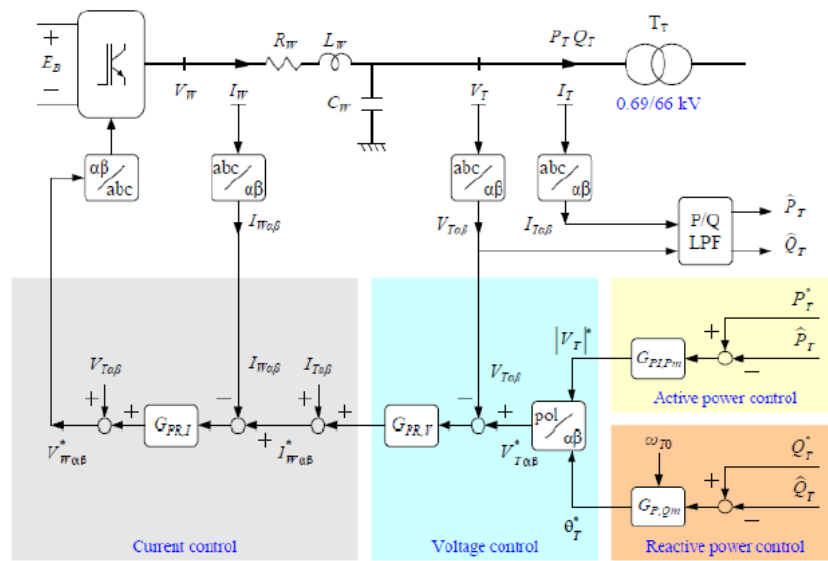
- Development and validation of impedance models of wind turbine and HVDC converters
- Analysis of harmonic stability and potential interactions of active components and the AC grid

Deliverable 16.5

Documentation of analytical approach

Implementation of an Analytical Method for Analysis of Harmonic Resonance Phenomena

- Wind Turbine Converters
- MMC-HVDC Converters
- DRU-connected Wind Turbines



MMC Testbench – Status Update



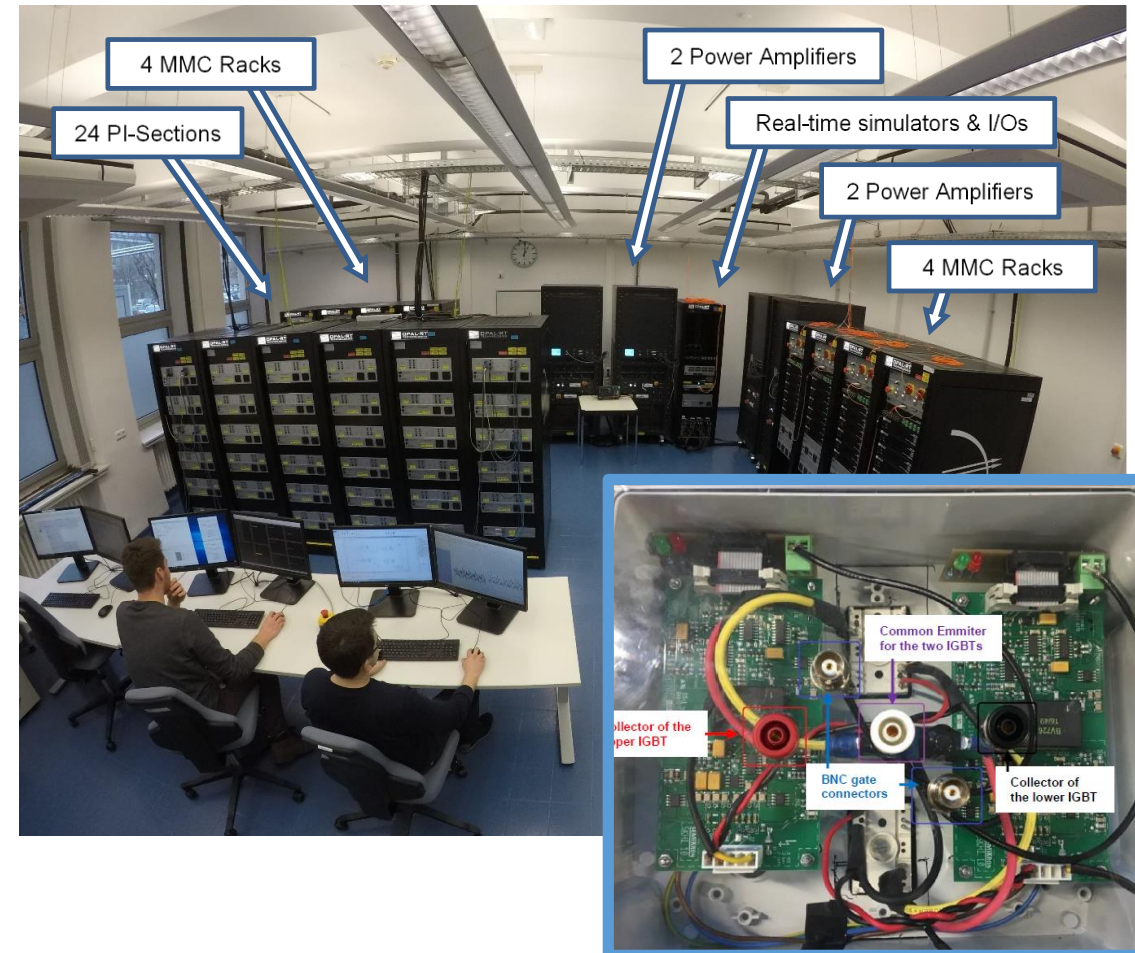
MMC Testbench – Status Update

Achievements:

- ✓ Physical assembly completed
- ✓ First Power-Hardware-in-the-Loop (PHiL) tests with PROMOTiON controls completed
- ✓ Milestone M75: First comparison between MMC Testbench and Simulations
- ✓ KTH Breaker

Next Steps:

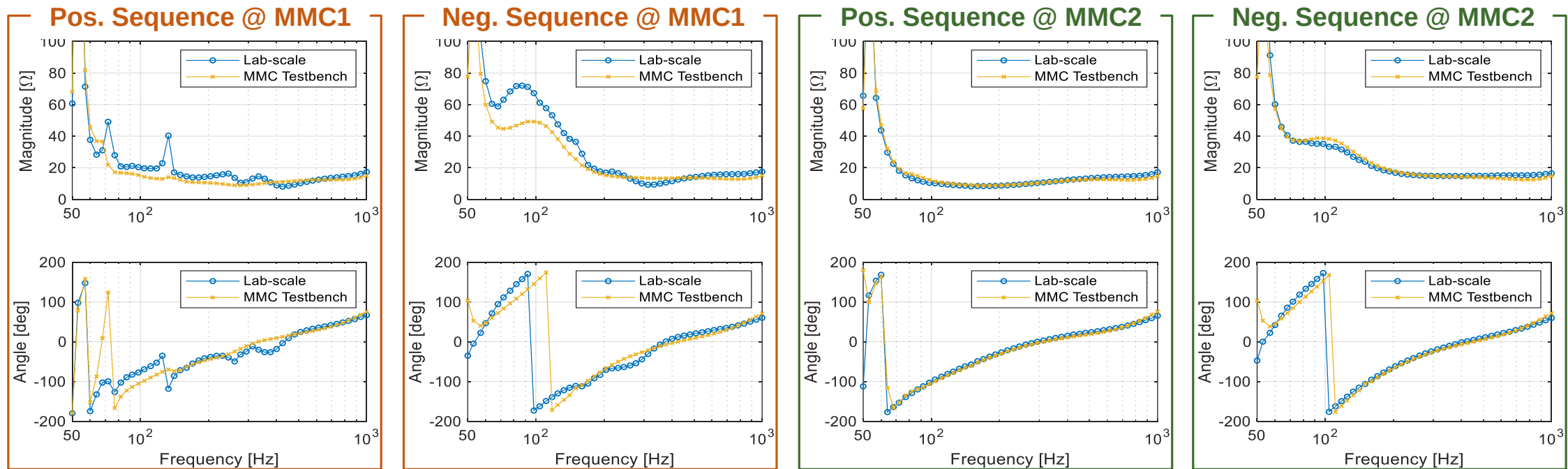
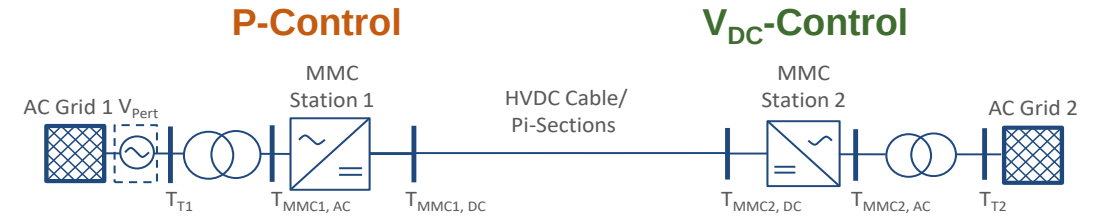
- Final testing and Integration of KTH small-scale HVDC Breaker
- Investigation of PHiL methods for OWP integration
- Integration of AC grid data to RTS (OWP and AC transmission grids)
- Impedance measurement of the MMCs



Milestone 75

First Test Results of the MMC Test Bench

- Logarithmic intervals ranging from 50 Hz to 1 kHz
- Comparison between simulation and the MMC Testbench



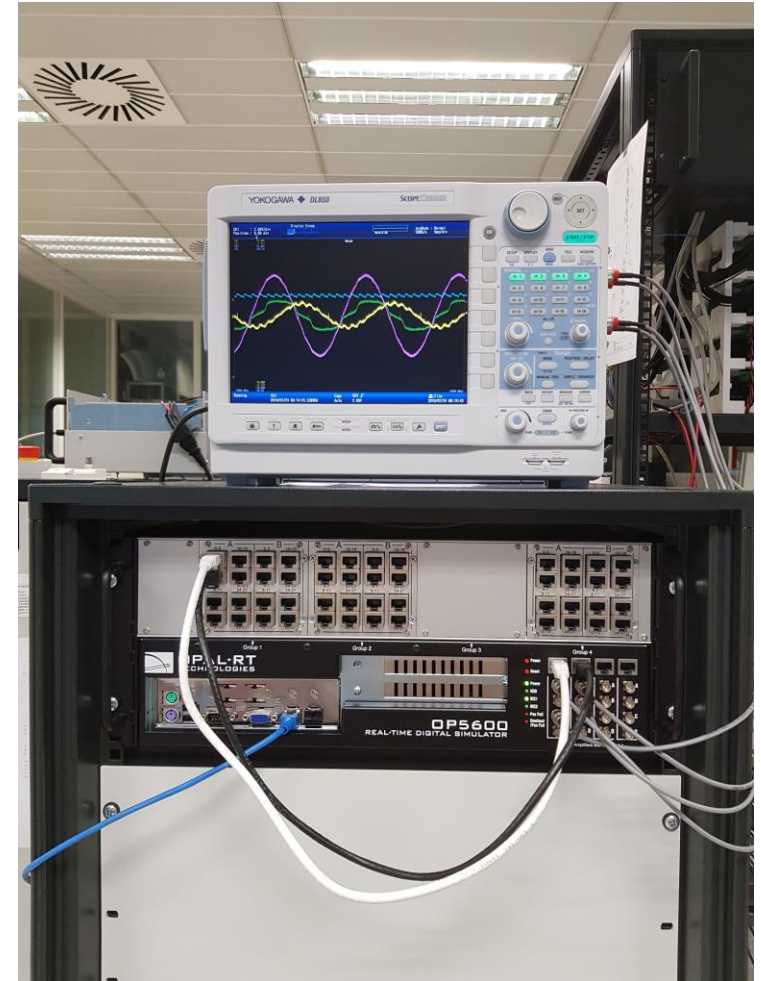
DRU/OWP - CHiL

Achievements:

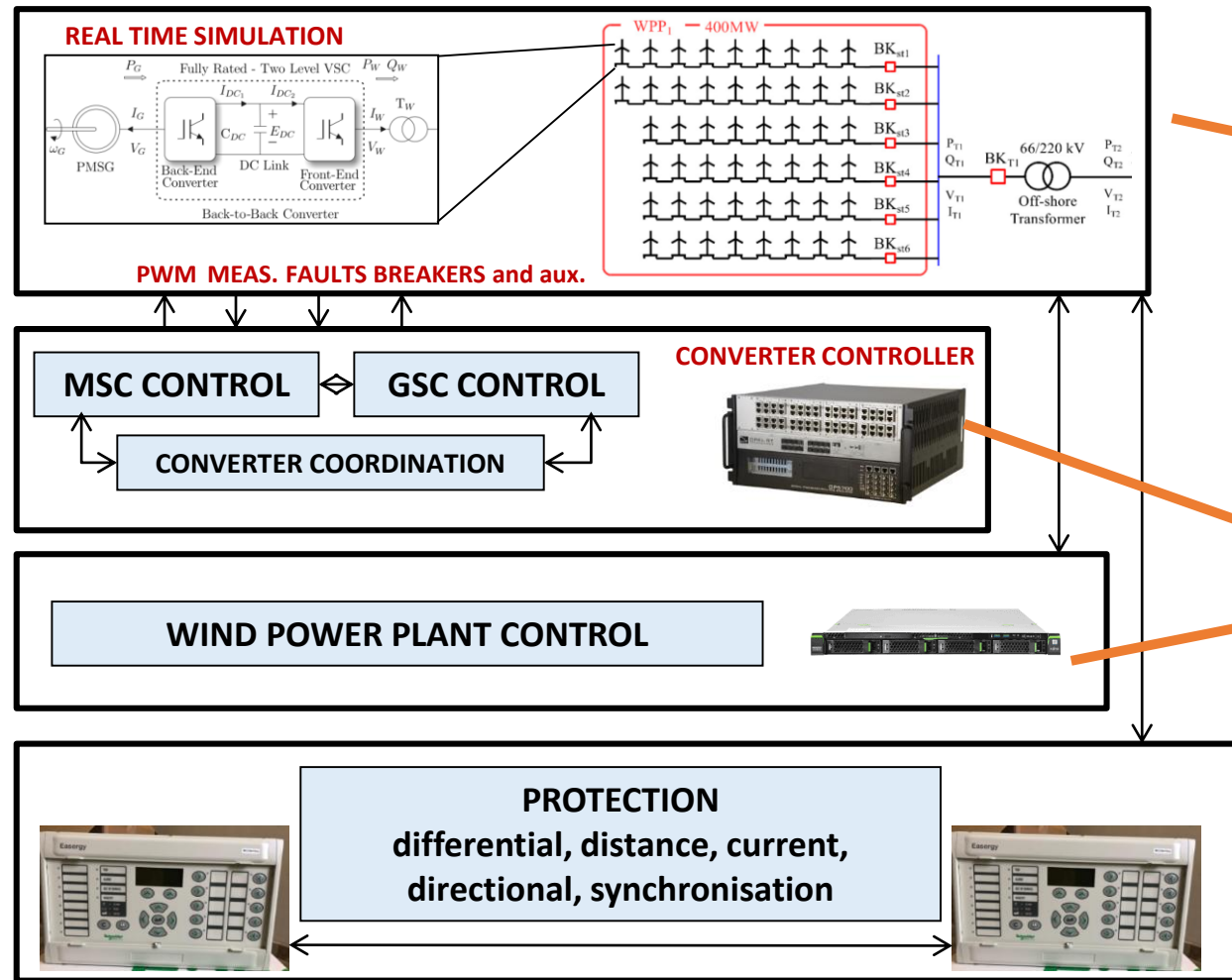
- ✓ Implementation of DRU models and wind turbine controls from WP3 on real-time simulators (RTS)
- ✓ commercial protection relay integrated into CHiL system

Next Steps

- Programming of the commercial protection relay
- Investigation of the Black Start Capability of HVAC and DRU-Connected OWP



DRU/OWP - CHiL



Harmonic Resonance Studies

Achievements:

- ✓ CHIL Wind Turbine Setup
- ✓ WT - CHIL Input Admittance Measurement and Validation Methodology Development
- ✓ Commissioning of WT CHIL test system
- ✓ “Online” Impedance Measurement Method

Next Steps

- MMC - CHIL Input Admittance Measurement and Validation Methodology Development of
- WT - PHIL Input Admittance Measurement and Validation Methodology Development of

Flexible Power Grid Lab @ DNV GL

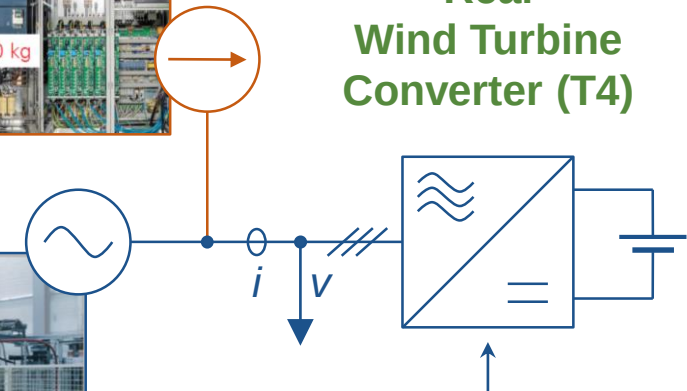
Harmonic injection
200 kW - PA



Real
Wind Turbine
Converter (T4)

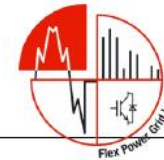


AC Grid Emulator



DUT (1 MW)

CHIL WTG – Input Admittance Measurement DETAIL CONNECTION



Any Questions?



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APPENDIX

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PROMOTioN – Progress on Meshed HVDC Offshore Transmission Networks
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