

Abstract

In order to design and analyze the offshore grid operation, **electrical simulation models** for the HVDC-connected Wind Turbines (WTs) and Offshore Wind Power Plants (OWPPs) are being provided **by the WT manufacturers** to be used mainly by OWPP developers. However, these models are usually **manufacturer specific confidential** blackbox models. There is a need for **generic and non-confidential model** structures, which can be configured and used by the WT manufacturers, OWPP developers, TSOs, HVDC manufacturers, and also research institutes; both for the project specific simulation studies and problem-solving oriented investigations.

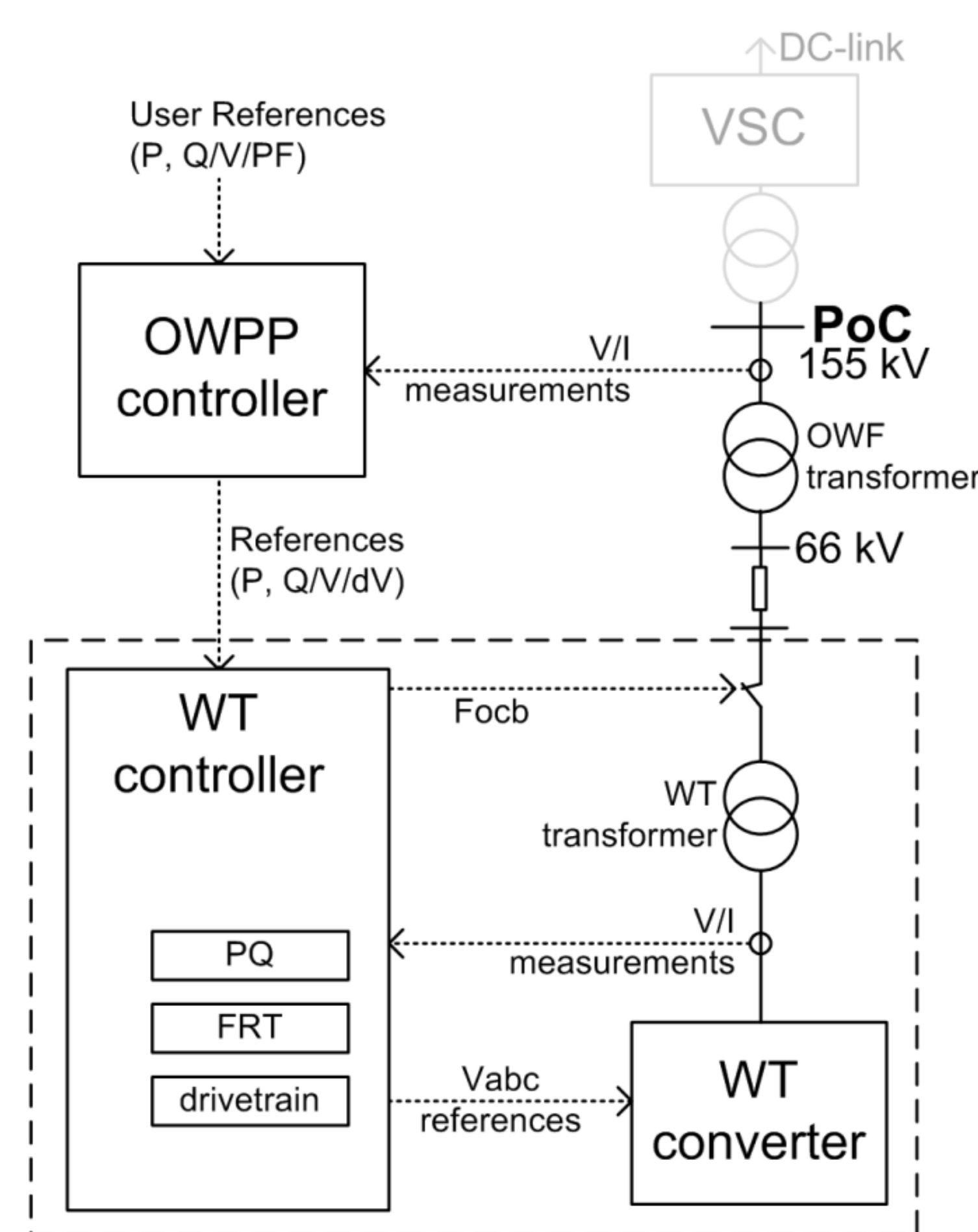
In this study, preliminary and generic HVDC-connected WT and OWPP electrical simulation models are proposed, **based on the IEC 61400-27** wind turbine modeling standard. This study is being considered as a **first step towards standard electrical models for HVDC-connected OWPPs**, which will help the industry to perform effective analysis and design studies for offshore grids.

Objectives

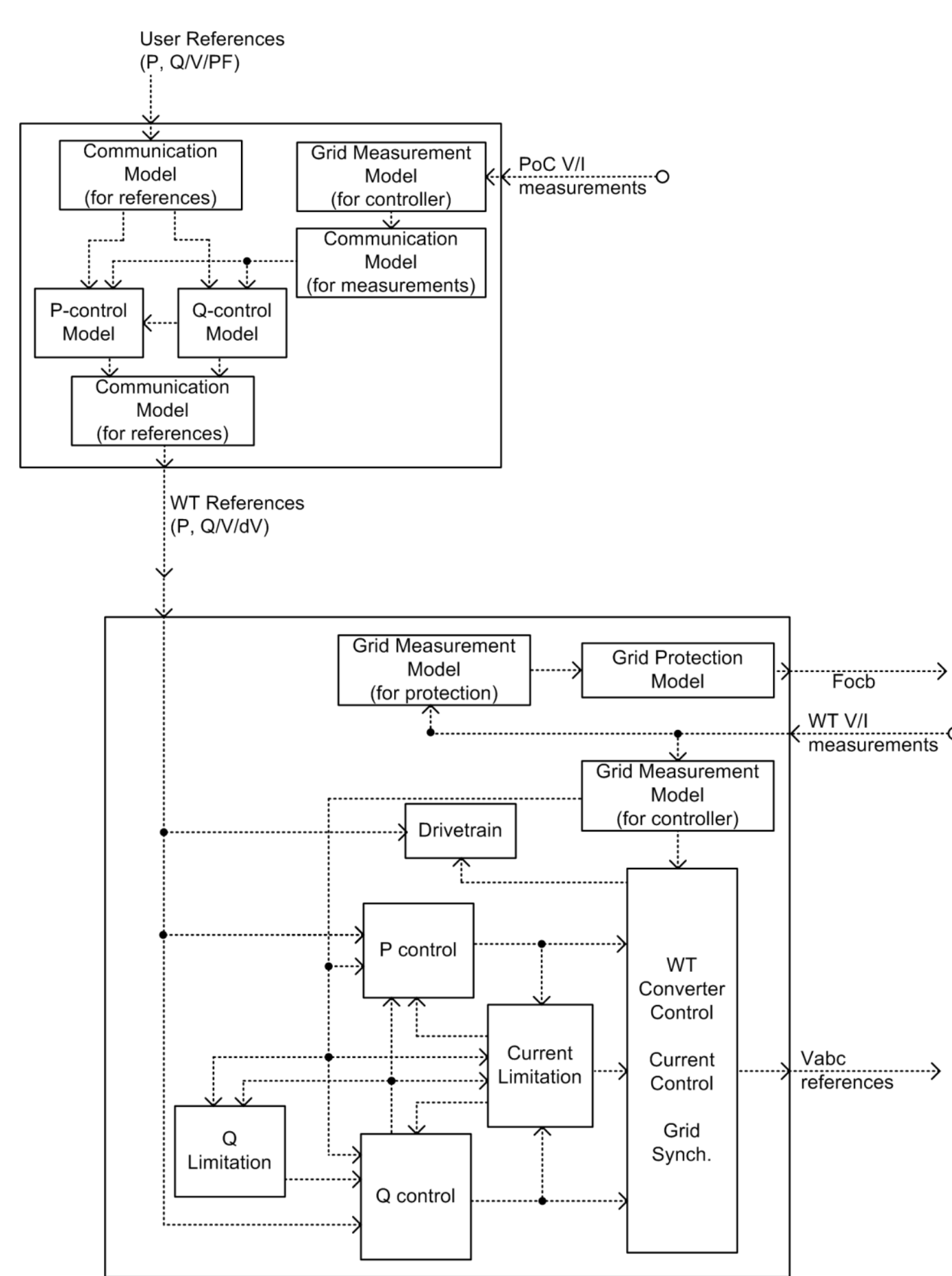
- to provide an understanding of the basic structure of the IEC 61400-27 standard WT model and its extended use with HVDC
- to provide generic open source modeling structure for HVDC-connected offshore WTs and OWPPs
- to enable the academia and industry to work towards standard models for HVDC-connected WTs and OWPPs
- to present the performance of the generic models and the overview of recent grid code requirements from HVDC-connected OWPPs

Results

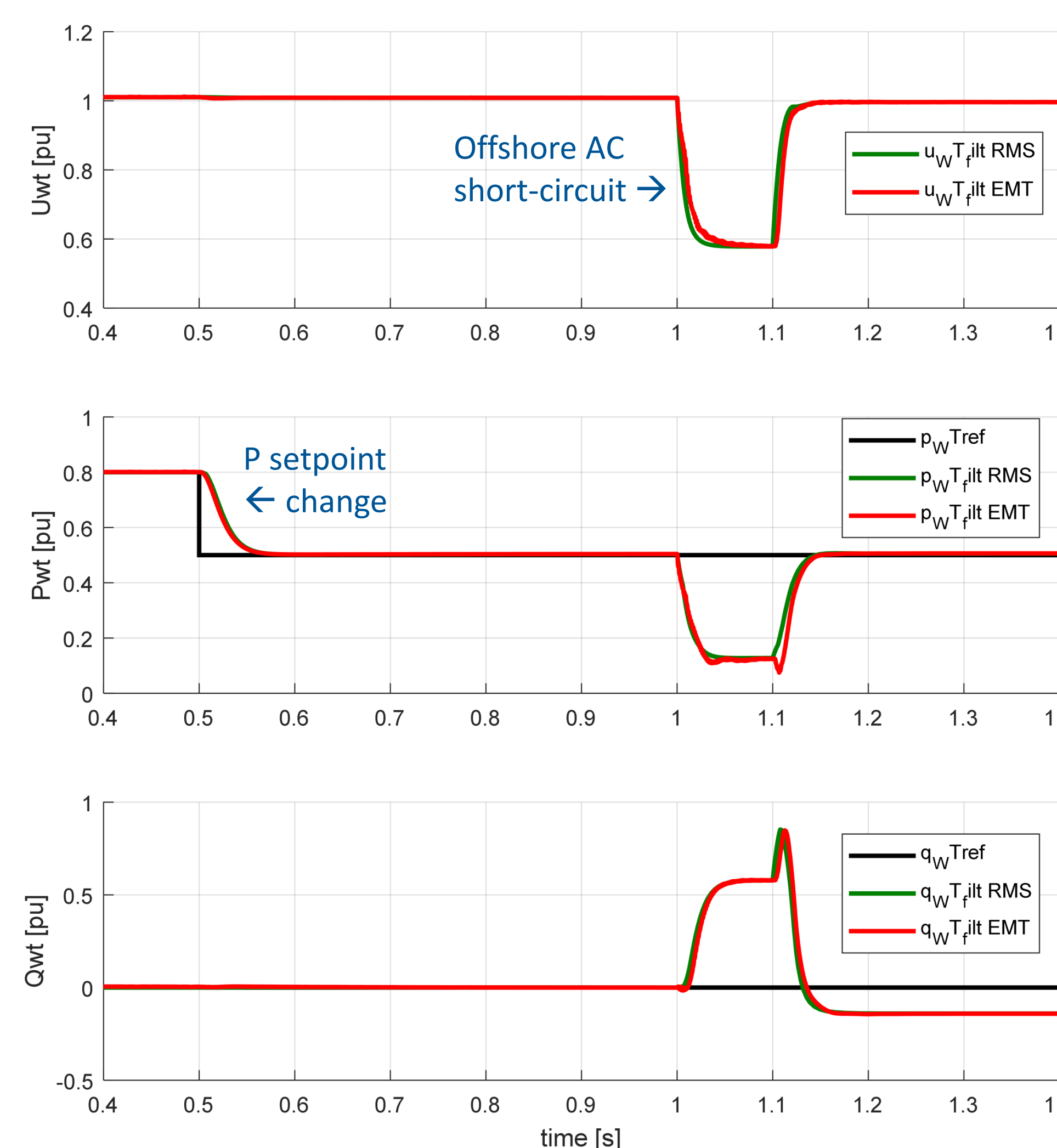
The performance of the developed models has been illustrated to perform the capabilities required by the grid codes, via simulation results. The developed WT and OWPP models are implemented using MATLAB Simulink software, while the SimScapePowerSystems toolbox is used for electrical components, both for root-mean-square (RMS) and electromagnetic transient (EMT) types. The developed RMS models have been compared against the detailed EMT models, which includes an **average-value converter model with grid synchronization (PLL) and current control blocks**.



Control Hierarchy:
OWPP & WT Controllers



Based on IEC 61400-27-1
(second edition draft version)



EMT: extension with
Current Controller, PLL, Average Value Model VSC

Conclusions

The simulation results show that the developed generic models can be utilized to represent the OWPPs performing the grid code required capabilities, while connected to HVDC converters. The open structure, which is based on the IEC 61400-27 standard, gives flexibility to investigate the offshore grid operation, such as during offshore faults and provision of system services to the onshore grid. Additionally, comparison of the RMS models against the EMT model gives insight about the validity range of the RMS models..

References

1. Wind Turbines—Part 27-1: Electrical Simulation Models - Wind Turbines, IEC Standard 61400-27-1 ed. 1, Feb. 2015
2. ENTSO-E Network Code on Requirements for Grid Connection of High Voltage Direct Current Systems and Direct Current-Connected Power Park Modules [online] Available: <https://www.entsoe.eu/Documents/Network%20codes%20doc>
3. <https://www.entsoe.eu/Documents/NC%20HVDC/EC%20Regulation%20%28EU%29%202016%201447%20HVDC%20network%20code.pdf>, 26 August 2016

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