

Study Committee B4 DC Systems & Power electronics

Paper ID_10406

Software-in-the-Loop Real-Time Simulation of a HVDC Terminal

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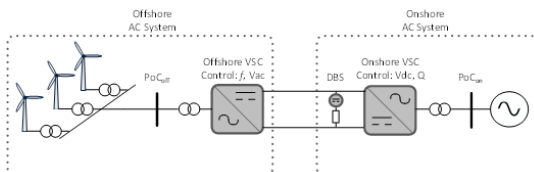
Motivation

- The need of real-time simulation to plan, test and investigate electrical power systems is growing but, ideally, the real control system of power system components are required to give realistic responses to simulated events
- The study investigated the use of a 'real-time black box platform' to host a vendors complete HVDC Control & Protection system for use in real-time simulation studies
- With the development of multi-terminal (multi-vendor) HVDC systems it may not be practicable to have real replicas for all existing, new and future HVDC converter connections, hence a 'real-time black box platform' facilitates the testing of such systems whilst maintaining individual vendors Intellectual Property

Method/Approach

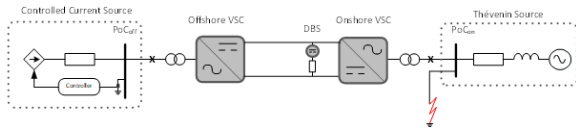
- Develop a method to integrate the code generation for the 'real-time black box platform' into the vendors workstream
- Find an appropriate disposition of the HVDC Control & Protection tasks between the 'real-time black box platform' processor cores to ensure correct code execution time is achieved
- Use the same Control & Protection system in conjunction with matching representation of the power circuit in both offline EMT and online real-time simulation to validate 'real-time black box platform' implementation
- A frequency scanning method has been applied to the Generic Vendor C&P source code in order to show if the 'real-time black box platform' is suitable for studies at super-harmonic frequencies

Objects of Investigation



A HVDC link was simulated in both offline and real-time simulation and the results compared

Experimental Setup & Test Results



In both the offline and real-time simulation the offshore windfarm was represented using a current source and AC side faults were simulated at the onshore converter bus.

Conditions studied include:

- Power Ramp
- 150 ms 1-phase fault at the onshore converter AC bus

Discussion

- The results of the studies performed show a good correlation between both the offline EMT simulation and the real-time simulation using a 'real-time black box platform'
- Small variations are observed which can be attributed to the frequency bandwidth of the measured signals from the power circuit, noting that this is influenced by the simulation time-step which is larger in the real-time simulation
- The frequency scan shows that the small-signal analysis can be applied to the real-time model to indicate potential harmonic issues

Conclusion

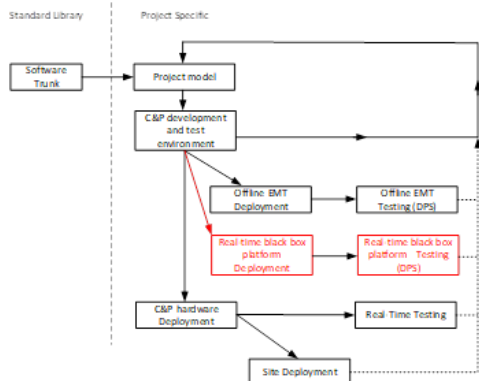
- A 'real-time black box platform' can be used within a real-time simulation system to accurately represent a vendors real HVDC converter solution

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HVDC Vendor Control & Protection development and deployment



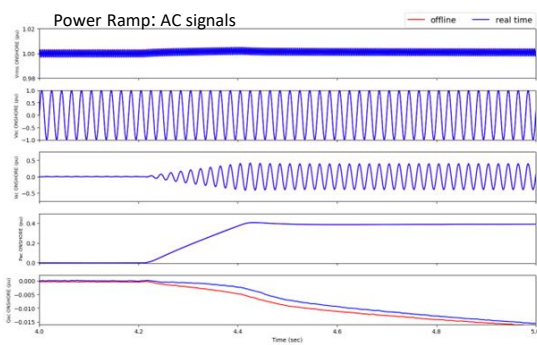
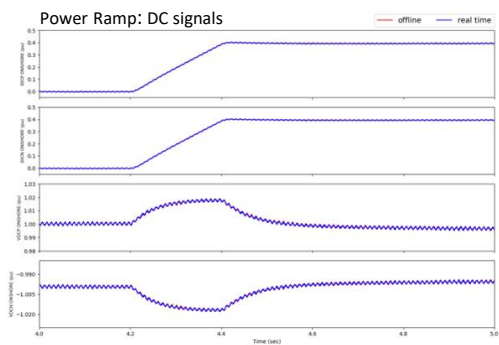
- Control and protection code is developed in one simulation platform and then exported as executable code to other simulation platforms as well as the actual vendor specific C&P hardware to be deployed on site.
- Addition of real-time black box platform to the vendor's standard approach

Fitting tasks into real-time simulation platform

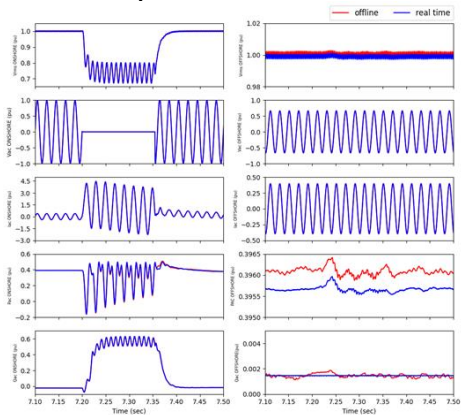


- Vendors Control & Protection consists of a number of 'tasks'
- Real-time black box platform has four cores on which to distribute the tasks whilst maintaining task run-time
- Necessary to arrange the various algorithm tasks in such a way that the tasks can be distributed amongst the cores and the total execution time of each core is less than the cycle time of the physical control and protection hardware
- Full Control & Protection are distributed on two Real-time black box platform totaling 8 eight cores

Dynamic Performance of a generic Vendor C&P system



150 ms 1-phase fault at onshore AC bus



Frequency scan (dq-0 frame) of onshore converter from the AC PCC

