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Parallelization of EMT solution for integration of IBR in large scale transmission grids

Context

EMT (ElectroMagnetic Transient) models are provided by wind turbine suppliers to RTE to carry out transient studies on the transmission grid. Models usually have capabilities to represent several Wind Turbine (WT) thanks to aggregation techniques. This simplification is commonly practiced because simulation of each individual turbine requires large computational resources and long simulation time. Aggregation of turbines is achieved with a device that multiplies line current generated by a turbine model by the number of wind generator to be simulated as shown in Figure 1.

Thanks to parallel simulation techniques it is possible to model each individual wind turbine and eventually remove the amplifier. When each wind turbine is solved separately on a single core it is possible to achieve the similar simulation time than with an aggregated model. Then, the main benefit of parallel computing is to be able to simulate a detailed wind park model without any aggregation technique.

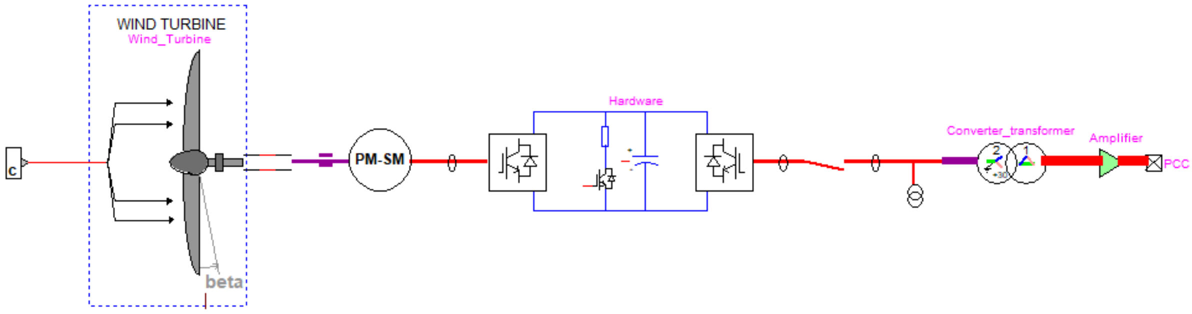

Figure 1 – Example of Type4 aggregated wind turbine model

Detailed wind park models and accuracy

System performance studies includes many difference types of studies such as energization, load step, Low Voltage Right Through (LVRT), OverVoltage Right Through (OVRT), load shedding… These types of studies require EMT simulation and better accuracy is achieved with detailed wind park model.

To simulate such a network in an EMT tool in a reasonable time, parallel computing is crucial. EMT model delivered by GE for the Saint-Nazaire Offshore Wind Power Plant (WPP) is designed to represent aggregated WT. It can also be used to represent individual WT as shown in Figure 2.

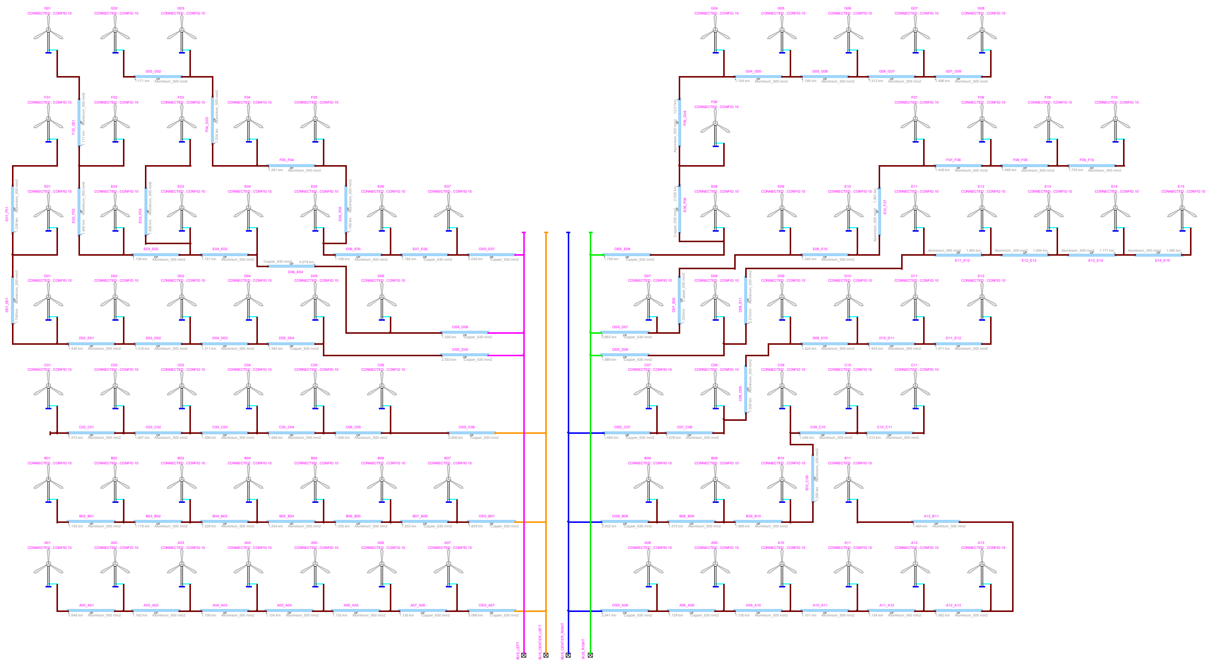

Figure 2 – Detailed view of the Saint Nazaire Offshore WPP with individual WT model in EMTP®

Parallelization of EMTP® via co-simulation

In this presentation, FMI-based co-simulation is used to link multiple instances of EMTP® through wind park cables. The intrinsic propagation delays of cables allow to naturally wind turbines and solve them on separate CPU cores. A co-simulation process is established, where each instance of EMTP® running on a separate processing unit, solves its own subnetwork and shares data through linking transmission lines at every time-step. This approach has major impact on computing time reduction.

Parallel comuting of the Saint-Nazaire Offshore WPP

The Saint-Nazaire WPP is composed of two parks of 240MW. Each park includes 40 WT. Each section has its own power plant controller (PPC) for this project. Each 240MW section is modeled identically. Each WT model is solved on an individual core and connected to the offshore system using existing cable models. 41 instances of EMTP® run in parallel (40 wind turbines + the offshore and onshore grid). The 33kV offshore grid presented in Figure 2 is connected to 2 step-up transformers (33kV/225kV) to the 225kV export cables. Onshore grid is represented by a Thevenin equivalent. The simulation time-step is fixed by the WTG model to 4 µs.

Parallel computation performance is shown in Table 1.

Test case (6.5s simulation)	Computation time (s)	Speed up
Reference case (1 CPU)	49,672	1
Parallel solution (41 CPU)	2037	24.38

Table 1 - Computation time for the detailed St Nazaire WPP model

Conclusion

Detailed model of WPP is usually not simulated with EMT tool. Simulation of detailed WPP model in a calculation time equivalent to the time requested to solve aggregated model is an important milestone for analysis of large scale WPP model.

References

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[2] https://www.services-rte.com/en/home.html