

Detailed Nonlinear Modeling and High-Fidelity Parallel Simulation of MMC With Embedded Energy Storage for Wind Farm Grid Integration

Ning Lin¹, BINGRONG SHANG², VENKATA DINAVAH²

¹Powertech Labs Inc., ²University of Alberta

Integration of renewable energy is increasingly prevalent, yet its stochasticity may compromise the stability of the power system. In this paper, a high-voltage dc (HVDC) link model based on the modular multilevel converter with embedded energy storage (MMC-EES) is presented and, utilizing the massively parallel computing feature of the graphics processing unit (GPU), its efficacy in compensating a varying wind energy generation is studied. Constant power is oriented in the inverter control by incorporating a DC-DC converter with EES into its submodules. High-fidelity electromagnetic transient modeling is conducted for insights into converter control and energy management. A fully iterative solution is carried out for the nonlinear model for high accuracy. Since the sequential data processing manner of the central processing unit (CPU) is prone to an extremely long simulation following an increase of component quantity with even one order of magnitude, the massively concurrent threading of the GPU is exploited. The computational challenges posed by the complexity of the MMC circuit are effectively tackled by circuit partitioning which separates nonlinearities. In the meantime, components of an identical attribute are designed as one kernel despite inhomogeneity. The proposed modeling and computing method is applied to a multi-terminal DC system with wind farms, and significant speedups over CPU-based simulation are achieved, with the accuracy validated by the offline simulation tool PSCAD.