A Heterogeneous Multiscale Method for Power System Simulation Considering Electromagnetic Transients

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MOTIVATION

- EMT simulation is time-consuming, as the model based on detailed component modeling is highly stiff.
- Very few papers have concerned the methodology for multiscale simulations of power systems considering EMT dynamics.

CHALLENGES

- Dynamic is very stiff, lack of necessary information for time averaging switch between different time-scale .

STEP OF PROPOSED HMM ALGORITHM

- Estimation of macro effective force:
  - ➢ Reconstruct information from the macro-model.
  - ➢ Solve micro-model (EMT) based on the micro solver.
  - ➢ Apply time averaging to the micro-model:

$$\bar{f}(t_n+\Delta t) \approx \tilde{f}_n = \tilde{f}(t_n+\Delta t) = K_\eta^{p,q} * f_\varepsilon(t_n+\Delta t)$$

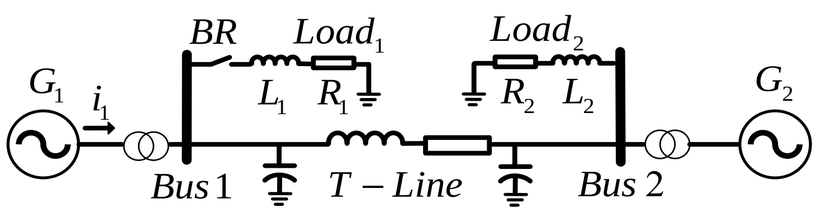
- Evolve the macro dynamics X^{n+1} for the next step:

$$X^{(n+1)} = \sum_{k=m}^{n} A_k X^{(k)} + H \sum_{k=m}^{n} B_k \tilde{f}_n + CX^*$$

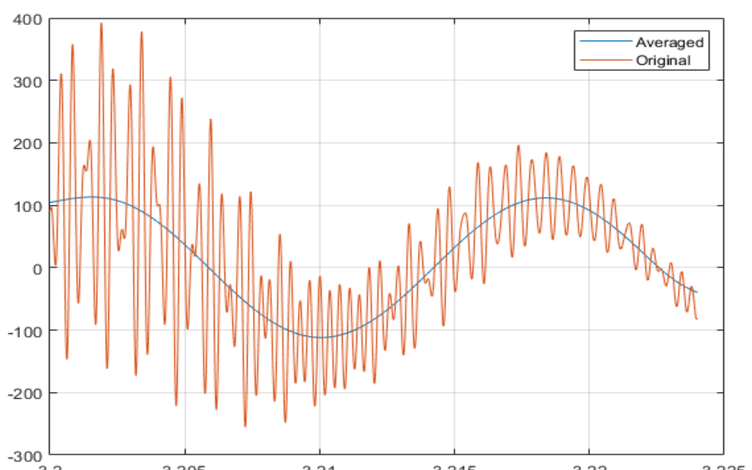
- Repeat the whole process.

COMPONENT SIZE

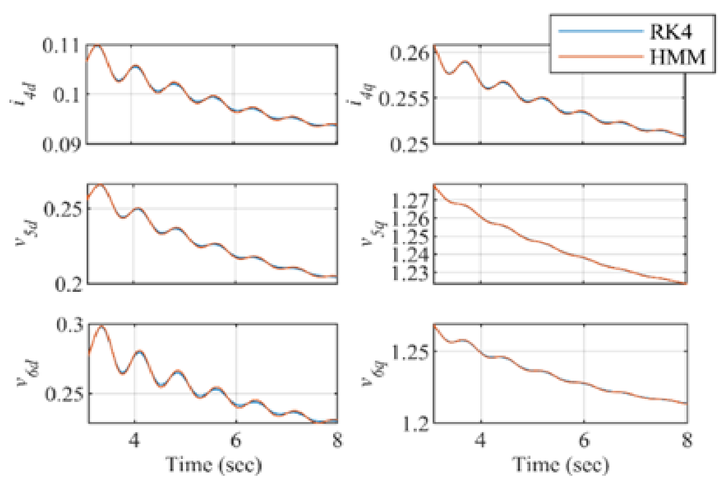
System Topology



Influence of kernel

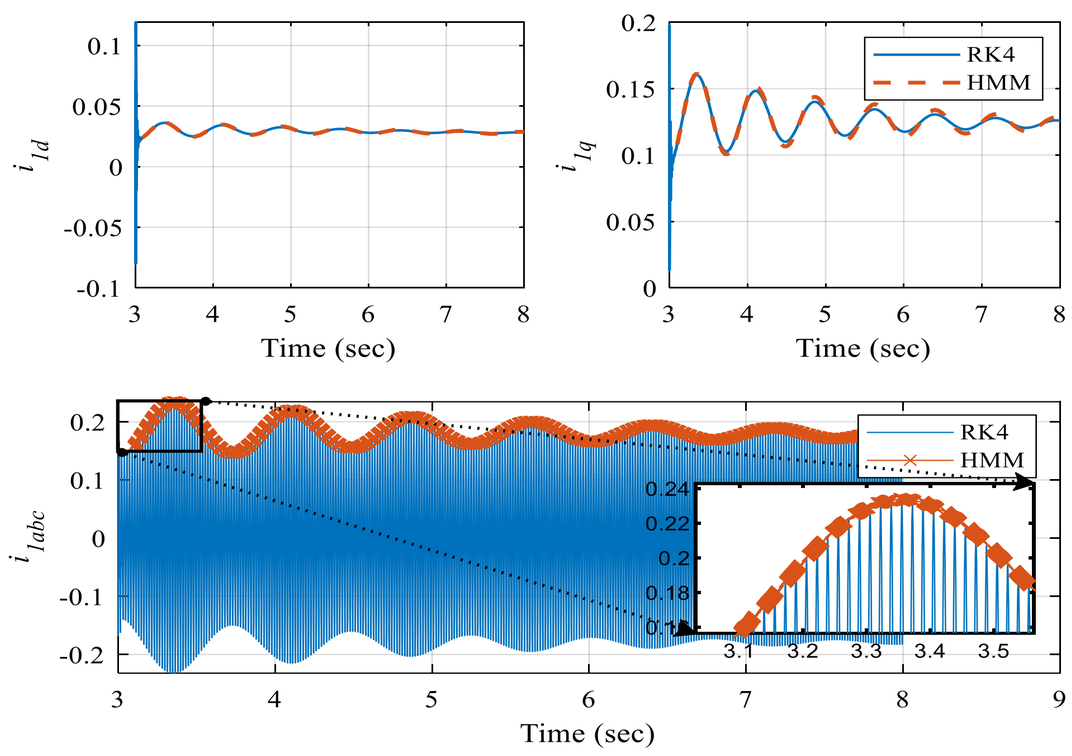


Effect on current

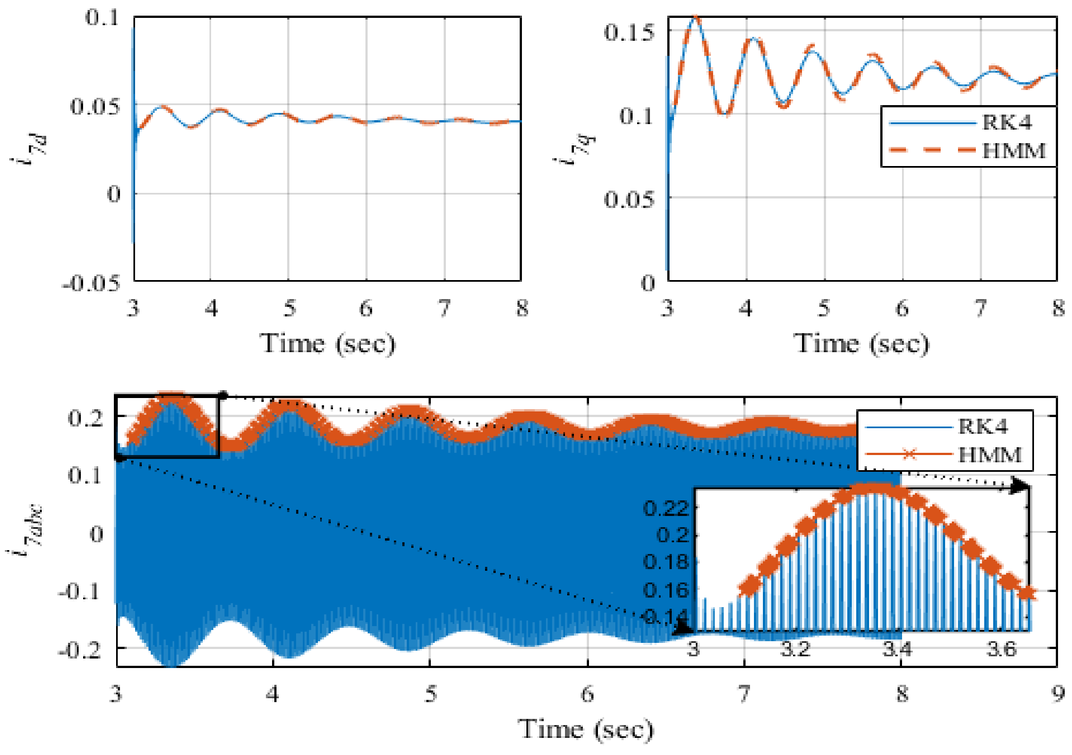


RESULTS

Converter size reduction @ different topologies



Converter size reduction @ different applications



CONCLUSION

- Apply the HMM to power system simulation to balance micro and macro dynamics in EMT simulation.
- HMM provides a general adaptive flexible frame to simulate a stiff system, time performance is improved as well as accuracy is preserved.
- For such an 8-second simulation, the ground truth EMT simulation shown before is used to compare with the HMM-based simulation. HMM-based simulation is finished with 80.931170s and RK4 one is 121.932214s which implies the power of HMM, a 33.63% speedup is achieved as a much larger time step is adopted during the macro simulations.

FUTURE WORK

- Apply a semi-analytical method in the micro process to speed up the simulation.
- Apply an adaptive step change to increase the time performance.