Construction of a general POD basis for faster Li-Ion cell simulations

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All electrochemical (EC) battery-models are complex and highly nonlinear. Thus, the numerical models are of large dimension and therefore computationally expensive, independent of the fact whether an finite element (FE) or finite volume approximation is used. In many applications, e.g., for optimization purposes, a speed-up of simulations is required. Here a speed-up in simulations is obtained by combining proper orthogonal decomposition (POD) with empirical interpolation method (EIM). Effort is made for the construction of a POD basis, which allows efficient simulation of different battery load cases.

Cai and White in [1] applied POD on Doyle-Fuller-Newman (DFN) model. In their work the mayor nonlinearity of the system was assumed to be constant in space. Starting from the full model, they obtained a speed-up factor of 7. A comparison between full and reduced model is made, only for constant discharge simulations. In [2] this approach was extended to include temperature, and the obtained speed-up factor reduced to 4.

In [6], Suhr and Rubeša followed the work introduced by Lass and Volkwein [3] and applied POD combined with the EIM. The used model is a fully nonlinear, extended, isothermal DFN model [4]. A speed-up factor of 10, for constant discharge simulations, is reported in [6]. Further, using the same battery model, the POD basis suitable for general battery behavior is built in [5]. More precisely, we constructed the POD basis that can simulate: charge/discharge at different C-Rates, pulses, constant voltage charge and rest steps. The major point of our investigation is on the set of snapshots that one should consider for POD basis construction as well as where a constructed POD basis should be cut. The solution of the obtained reduced-order model (ROM) agrees well with the solution of FE method, compare Figure 1, and requires 14 times less computation time than FE model.

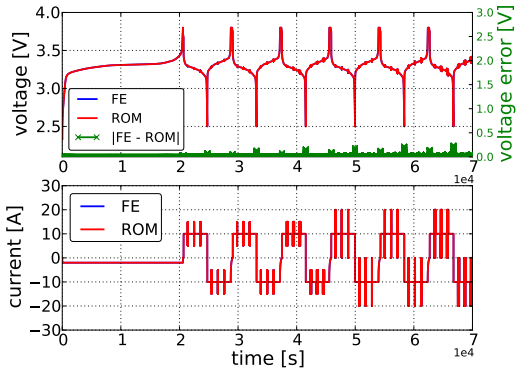

Figure 1: Current-voltage profile for FE and ROM.

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