A PGD solver for the Parametric Power Flow Problem: modeling electric grids with accuracy assessment and control

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ABSTRACT

Accurate modeling of electric grids is essential to achieve a safe, reliable and sustainable electricity supply, especially if renewable power sources participate in the network. This is because, the new energy mix requires ever complex maintenance, monitoring, and control operations.

The behaviour of an electrical grid is determined by the power flow problem, resulting in a nonlinear algebraic system of equations. Modeling for optimization and control involves repetitive queries, simulating many diverse scenarios that are described by a parametric version of the problem. For instance, demand and supply loads or other characteristics of the network can be considered as parameters. Consequently, the problem is stated in a multidimensional setup, being each parameter an additional dimension.

Proper Generalized Decomposition (PGD) [1] is devised as a Reduced Order Model (ROM) mitigating the effect of the curse of multidimensionality by using the idea of variable separation combined with a greedy algorithm and an alternated directions nonlinear solver. Hence, PGD is particularly well suited to deal with the parametric version of the Parametric Power Flow Problem. Using PGD in this context requires a particular strategy to solve the resulting nonlinear algebraic system. Here, we adopted the Z bus method [2] due to its simplicity that allows easily interacting with PGD.

The drastic cost savings associated with PGD may undertake a reduction in accuracy and, consequently, an error assessment strategy is needed. This has already been addressed in different contexts [3,4]. Here, we focus on expressing the error committed when we calculate the system losses using PGD. Consequently, the Quantity of Interest (QoI) to be assessed are the system power losses and the corresponding dual problem is introduced to make use of the goal-oriented error assessment. Different sources of error are taken into account since the approach is characterized by an iterative scheme and the traditional PGD strategy. Thus, error may arise in the fixed point algorithm or in the truncation of the separated representation of the solution in the enrichment process. Numerical results are presented, demonstrating the robustness of the proposed methodology.

References

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