## ADI-preconditioned GMRES for solving large Lyapunov equations - A case study

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## Abstract

Solving large Lyapunov equations plays a central role in model order reduction, e.g., when applying Hankel-norm approximation or balanced truncation. A Lyapunov equation is a linear matrix equation of the following type

$$AX + XA^T = -RR^T {.} (1)$$

Since the right hand side usually does not have full rank and the dimension of the equation can be very large we are only interested in finding a low rank Cholesky-like factorization of the solution X. To do this we use the **F-GMRES** (flexible GMRES) algorithm as proposed in [Saa93] and apply it to Lyapunov equations. The advantage of this approach is that in every step a different preconditioner can be applied. As preconditioner we apply the **ADI** (alternating direct implicit iteration) algorithm [LW02] rather than solving the entire system. The combined approach generalized earlier work in [Dam08].

We will present numerical results for a case study of this new approach to show the effectiveness. Later we plan to apply this to the generalized Lyapunov equations arising in circuit simulation.

## References

- [Dam08] Tobias Damm. Direct methods and ADI-preconditioned Krylov subspace methods for generalized Lyapunoc equations. 2008.
- [LW02] Jing-Rebecca Li and Jacob White. Low Rank Solution of Lyapunov Equations. SIAM J. Matrix Anal. Appl., 24(1):260–280, 2002.
- [Saa93] Youcef Saad. A flexible inner-outer preconditioned GMRES algorithm. SIAM Journal on Scientific Computing, 14(2):461–469, 1993.