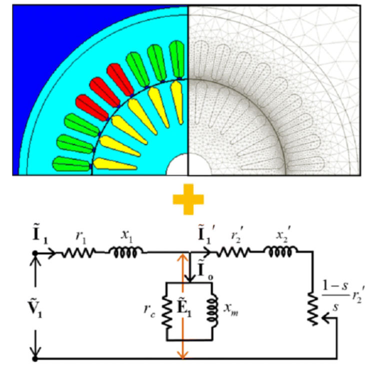
# Bachelor Thesis



**Topic:** Efficient solvers for nonlinear time-periodic problems
**Student:** tba
**Supervisor:** Herbert Egger

**Outline.** We consider nonlinear boundary value problems of the form

$$\partial_t x = f(x) \qquad \text{on } [0,T] \tag{1}$$
$$x(0) = x(T) \tag{2}$$

which frequently arise in the mathematical modelling of technical systems, like electric circuits or multibody dynamics. A standard approach to the numerical solution of (1)–(2) are *shooting methods*. The idea is to find an initial datum $z$ such that the solution of

$$\partial_t x = f(x) \qquad \text{on } [0,T] \tag{3}$$
$$x(0) = z \tag{4}$$

coincides with the solution of the time-periodic problem (1)–(2). Let $F : z \mapsto x(T)$ be the solution map of the initial value problem (3)–(4). Then (2) amounts to the nonlinear equation

$$z = F(z), \tag{5}$$

which can apply the Newton method or certain variants of it. Damping or a reduction of the time-interval, leading to *multiple-shooting*, are applied in order to ensure global convergence. Another approach is to express the solution of (1)–(2) by a Fourier series

$$x(t) = \sum\nolimits_n x_n e^{in2\pi t/T}. \tag{6}$$

After truncating at a finite number of terms, one usually requires (1) to hold for a finite number of points $t^n$, which is called a *collocation* approach. Alternatively, one might also enforce (1) approximately in a least-squares sense, leading to the *harmonic balance* method.

**Scope.** The goal of the thesis is to study an compare different state-of-the-art numerical methods for the solution of nonlinear time-dependent problems. As a typical application, we consider nonlinear electric circuits, but the results may be tested also for time-periodic eddy-current problems of relevance in electric machine simulation.

### References


- K. Strehmel, R. Weiner, and H. Podhaisky: Numerik gewöhnlicher Differentialgleichungen. Springer 2012.
- Z. Yan, H. Dai, Q. Wang, and S. N. Atluri: Harmonic Balance Methods: A Review and Recent Developments, Comput. Model. Eng. Sci., 2023.