Port-Hamiltonian approach for field/circuit coupling of the foil conductor model
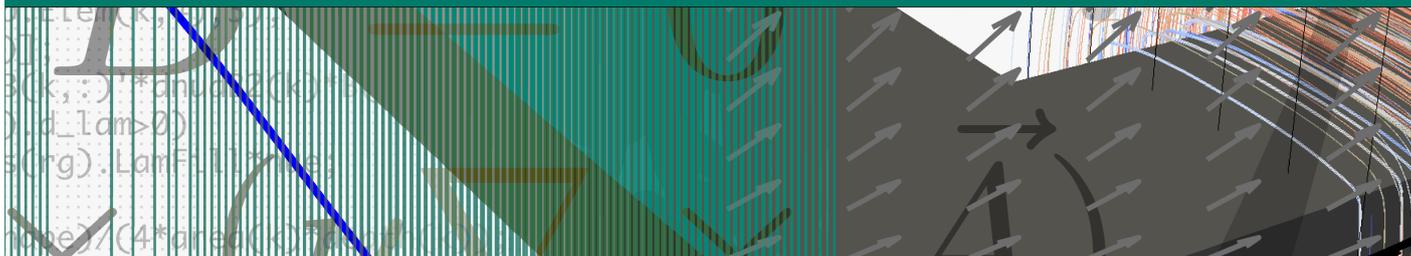
Proposal for a Bachelor's thesis | Master's thesis | seminar topic
Study field: Computational Engineering | Electrical Engineering | Mathematics
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Description

Systems with port-Hamiltonian (pH) structure have several beneficial properties, such as power balance and passivity. Moreover, the interconnection of pH systems results in a system that preserves the pH structure [1]. Recently, an energy-based pH framework for field/circuit coupled systems has been proposed [2]. The framework enables the pH structure to be proven for systems containing both field models and circuits, for example in the three-phase transformer shown in Fig. 1.

The goal of this project is to show the effectiveness of the proposed framework for systems containing *foil conductors*. This necessitates implementing a structure-preserving interconnection for the foil conductor model.

Work plan

- Implementing the coupling between the circuit and the foil conductor model within a port-Hamiltonian framework.

- Demonstrating the conservation of energy in the coupled system.

- Further steps may include more complex geometries and circuits, or the modeling of nonlinear systems.

Prerequisites

Motivation and interest in numerical methods, as well as experience in programming (e.g., Python and/or Matlab) are essential. Knowledge of the finite element method is beneficial but not required.

References

[1] A.J. van der Schaft and D. Jeltsema, "Port-Hamiltonian systems theory: an introductory overview," *Found. Trends Syst. Control* 2014.

[2] R. Altmann, I. Cortes Garcia, E. Paakkunainen, P. Schulze, and S. Schöps, "Energy-based modeling for field-circuit coupling," *Appl. Math. Model.* 2026.

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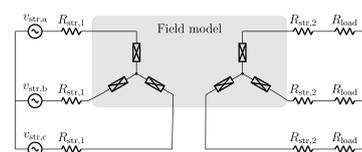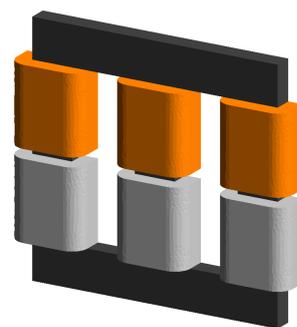tu-darmstadt.de

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Figure 1: Field/circuit coupled three-phase transformer model.