

Validity of Equivalent Circuit Models for Transient Analysis of Superconducting Magnets

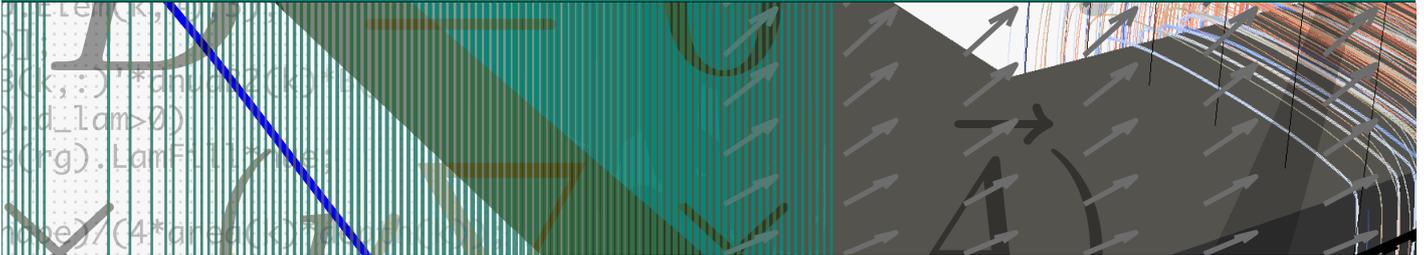


TECHNISCHE
UNIVERSITÄT
DARMSTADT

Proposal for a Bachelor's or Master's thesis

Study interests: Computational Engineering | Electrical Engineering | Applied Physics

March 4, 2026



Description

This project investigates the validity of equivalent circuit models for the transient analysis of superconducting magnets. Superconducting magnets exhibit complex magneto-thermal behavior during dynamic events such as quenches and current ramps. The study compares simplified equivalent circuit approaches with detailed multiphysics simulations to evaluate their accuracy and limitations. Key performance metrics include voltage evolution, and thermal response during transients. The results aim to assess whether equivalent circuit models provide a reliable and computationally efficient alternative.

In particular, reduced-order circuit representations will be implemented in Xyce [1]. They are benchmarked against existing high-fidelity finite element models developed within CERN's Finite Element Quench Simulator (FiQuS) [2]. While Xyce enables efficient transient simulations based on lumped parameter networks, FiQuS resolves the coupled electromagnetic and thermal fields in two- or three-dimensional space. By systematically comparing both approaches under representative operating scenarios, the project quantifies the trade-offs between computational cost, modeling complexity, and predictive accuracy.

Prerequisites

- Proficiency with circuit solvers such as XYCE or interest to learn
- Experience in the interpretation/comparison of simulation results
- Programming experience, preferably in Python, would be helpful

References

- [1] S. Hutchinson et al., *The Xyce™ Parallel Electronic Simulator – An Overview*. Parallel Comp., 2002. doi: 10.1142/9781860949630_0021
- [2] A. Vitrano et al., *An Open-Source Finite Element Quench Simulation Tool for Superconducting Magnets*. IEEE TAS, 2023. doi: 10.1109/TASC.2023.3259332
- [3] S. Atalay et al., *An open-source 3D FE quench simulation tool for no-insulation HTS pancake coils*. SUST, 2024. doi: 10.1088/1361-6668/ad3f83

Supervisors:

Dr.-Ing. Erik Schnaubelt

Dr. Mariusz Wozniak

Prof. Dr. Sebastian Schöps

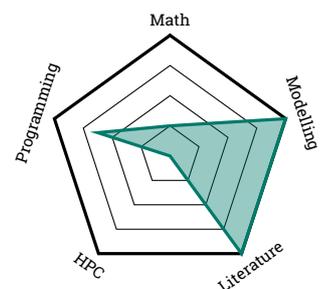
Contact:

erik.schnaubelt@cern.ch

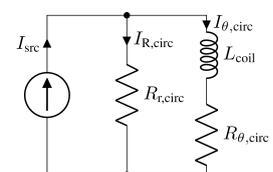
sebastian.schoeps@

tu-darmstadt.de

Weighted Core Areas:



FE geometry [3]



Simplified circuit model

