Reduced magnetic vector potential formulation of the magnetoquasistatic Maxwell equations

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MSc-thesis or Project/HiWi Work
Study field: Electrical Engineering / Computational Engineering
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Description The reduced magnetic vector potential (RMVP) formulation has recently been used to drastically speed up the simulation of accelerator magnets at CERN [1]. The formulation decomposes the magnetic vector potential into several components, depending on the different subdomains of the computational domain. With the currents in a coil being known, it starts by computing a source magnetic vector potential with Biot-Savart's law and proceeds with the corrections towards the total solution. In this process, the magnetostatic Maxwell equations are used.

Extending the reduced magnetic vector potential formulation to the magnetoquaistatic Maxwell equations is not straightforward. Due to the eddy currents, the current distribution in conducting domains is not known beforehand and depends on the surrounding domain. This causes errors in the total solution. It is expected that an iterative scheme that iterates between the different domains can effectively account for the eddy current effects.

Task

- Show the poor performance of the RMVP formulation for higher frequencies
- Formulate the iterative scheme to come up for the eddy current effects
- Implement this method in GetDP[1] (alternatively in Python with Pyrit [2]) and conduct numerical experiments

Prerequisites

- Strong understanding of Maxwell's equations
- Good programming skills in Python
- Interest in numerical methods and field simulation

References

[1] L. A. M. D'Angelo et al., "Efficient reduced magnetic vector potential formulation for the magnetic field simulation of accelerator magnets," *IEEE Trans. Magn.*, vol. 60, no. 3, pp. 1–8, Mar. 2024. DOI: 10.1109/tmag.2024.3352113

[2] J. Bundschuh et al., "Pyrit: A finite element based field simulation software written in python," *COMPEL*, vol. 42, no. 5, pp. 1007–1018, 2023. DOI: 10.1108/compel-01-2023-0013

[1] https://www.getdp.info/