Discretising Multi-Conductor Systems

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In electromagnetic devices, coils can be applied to transduce electrical energy or to measure magnetic fields. Multi-conductor systems feature complicated geometries with conducting wires, foils or bars, insulation material, cooling ducts and mechanical supports. The importance and nature of the encountered skin effect depends on the geometrical dimensions, the excitation frequencies and the permeabilities and conductivities of the materials. Meshing the realistic geometry and considering the true winding scheme introduces an unnecessary burden in the computation of the eddy current effects. Here, instead, continuum models are applied. The solid and stranded conductor paradigms serve as limit configurations, the former fully considering induced currents, the latter, neglecting them. Many multi-conductor systems, however, do not align with one of these approximations. In foil conductors, the current redistributes only in one direction. A foil winding model is proposed, assigning an additional 1-dimensional discretisation to the voltage varying in the direction perpendicular to the foils, and weighting the integral relations for the currents by the corresponding shape functions. For wire windings experiencing reduced eddy currents, a checkboard pattern serves as a discretisation for the voltage and for weighting the current homogenuity condition. The electric and magnetic meshes do not have to coincide. This enables independent adaptive mesh refinement, yielding e.g. fine magnetic meshes at the tips of the foils and in subregions of coils suffering from huge proximity effects. The described discretisation techniques are applied to examples of technical relevance. A grid transformer with foil windings is simulated, attaining the prescribed accuracy with a factor 10 less unknowns and a factor 100 less computation time.

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