Three-dimensional modeling of multilayer busbar incorporating domains of lesser dimension

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Busbars are commonly used for power distribution in a variety of applications including circuit coupling and load control. Due to the diversity in functionality, their size and shape vary substantially from design to design, although their main concept resembles that of a parallel-plate transmission line, consisting of parallel conducting plates separated by a dielectric slab.

The efficient design and optimization of electromagnetic devices encompass the development of comprehensive simulation models to enable deep understanding of their behavior and performance. The design of a busbar is similar to the approach used in transmission lines. This means that the calculation of the input impedance is critical to be able to work in harmony with other electrical equipment, and avoid malfunction at resonant frequencies.

For the accurate modeling of a busbar it is needed to solve the full-wave Maxwell's equations, to include inductive and capacitive effects, in the calculation of the input impedance. Furthermore, operation at higher frequencies is costly as the skin depth becomes smaller than the thickness of the conducting domain. The challenge therein lies in finding a trade-off between computational cost and the accuracy of the solution.

This paper describes the efficient modeling of a three-dimensional busbar, starting from a time-harmonic full-wave finite-element model, modifying the formulation to account for the skin effect, avoiding the need for explicitly modeling the volumes of the conducting domains. This is performed by specifying jacobian methods on the geometrical transformations based on their dimension (3D, 2D or 1D).