Semi-analytical Method for the Modeling of Thin Wires Taking Skin- and Proximity Effects into Account

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The modeling of wires becomes computationally prohibitive at higher frequencies as an extremely fine mesh is needed to capture skin and proximity effects. This culminates in a compromise between accuracy and memory requirements that limits the modeling of complex systems of conductors.

In this paper we present a hybrid method in which we combine the Finite-Element solution of the $\mathbf{a}-v$ formulation with the analytical solution of a single conductor in isolation, namely the *Semi-Analytical* method. This method exploits the properties of nodal basis functions substituting a fully discretized round conductor by a node in the mesh. This substitution requires the appropiate treatment in the weak formulation to obtain the background field solution (i.e. truncated field). The frequency-dependent distribution of the magnetic vector potential can be then reconstructed by adding up the analytical solution to the truncated-field solution in the finite-element model, naturally falling onto a one liner description:

$$\mathbf{a} = \mathbf{a}^c - \mathbf{a}^w + \mathbf{a}_{corr} \tag{1}$$

where $\mathbf{a}^c - \mathbf{a}^w$ is the truncated field of the vector magnetic potential finite element potential and $\mathbf{a}_{corr} = \mathbf{a}_{corr_s} + \mathbf{a}_{corr_p}$ is the analytical solution of a single round conductor in isolation including both: skin- and proximity effects.

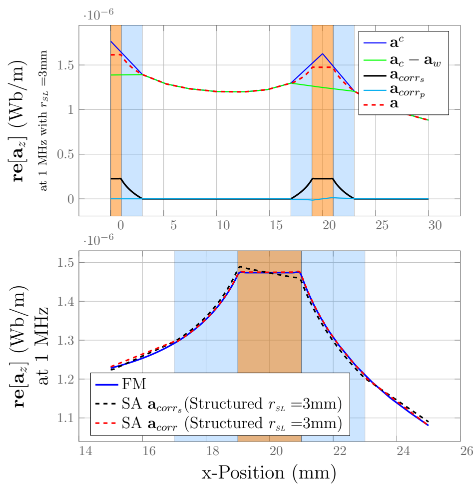

Figure 1: Semi-analytical reconstruction of the Magnetic Vector Potential at 1MHz (Top) and Semi-analytical vs. Fully Discretized Model comparison (Bottom)