Self-consistent Modeling of Thin Conducting Wires and their Interaction with the Surrounding Electromagnetic Field

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Introduction: It is demonstrated how the RF module can be used to approximately model thin conducting wires or cables and how they interact with a surrounding electromagnetic field. Despite being non-stringent the method can reasonably well predict currents induced by an applied electromagnetic field in wires, and networks of wires, as well as fields radiated from current-carrying wires (antennas).

Figure 1. An example where electromagnetic interference (EMI) between cables is very difficult to model using conventional FEM techniques.

Computational Methods: Combine the electromagnetic wave and transmission line nodes. Use a modified version of the Telegrapher´s equation:

$$\frac{\partial}{\partial x}\left(\frac{1}{R+i\omega L_w}\left(\frac{\partial V}{\partial x}-E_x\right)\right)-(G+i\omega C_w)V=0$$

$$I=\frac{1}{R+i\omega L}\left(E_x-\frac{\partial V}{\partial x}\right)$$

Global Electric field

Results: (i) Closed loop in magnetic field:

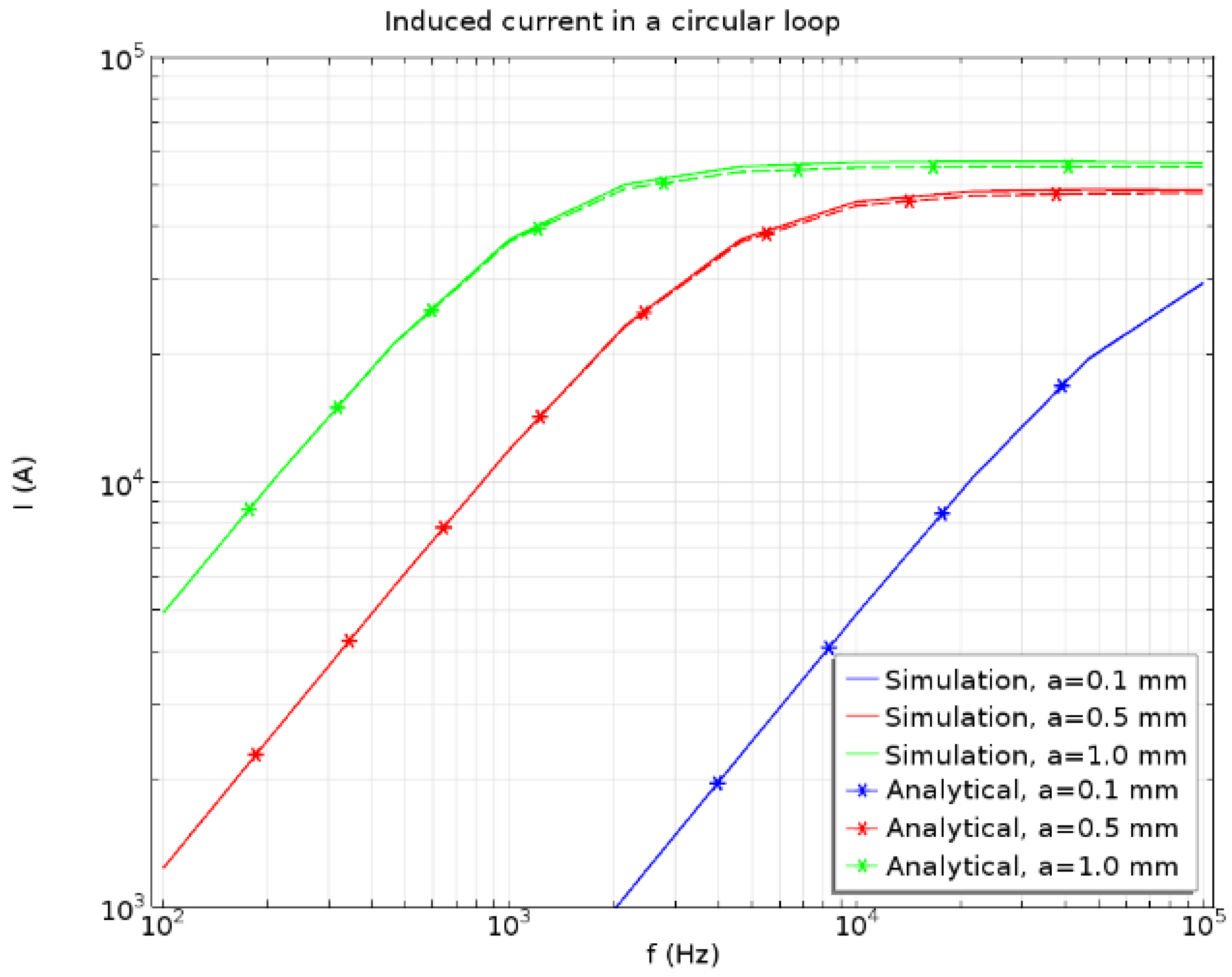

Figure 2. Comparison between simulated and analytical results for different wire radii.

(ii) Radiating wire dipole antenna:

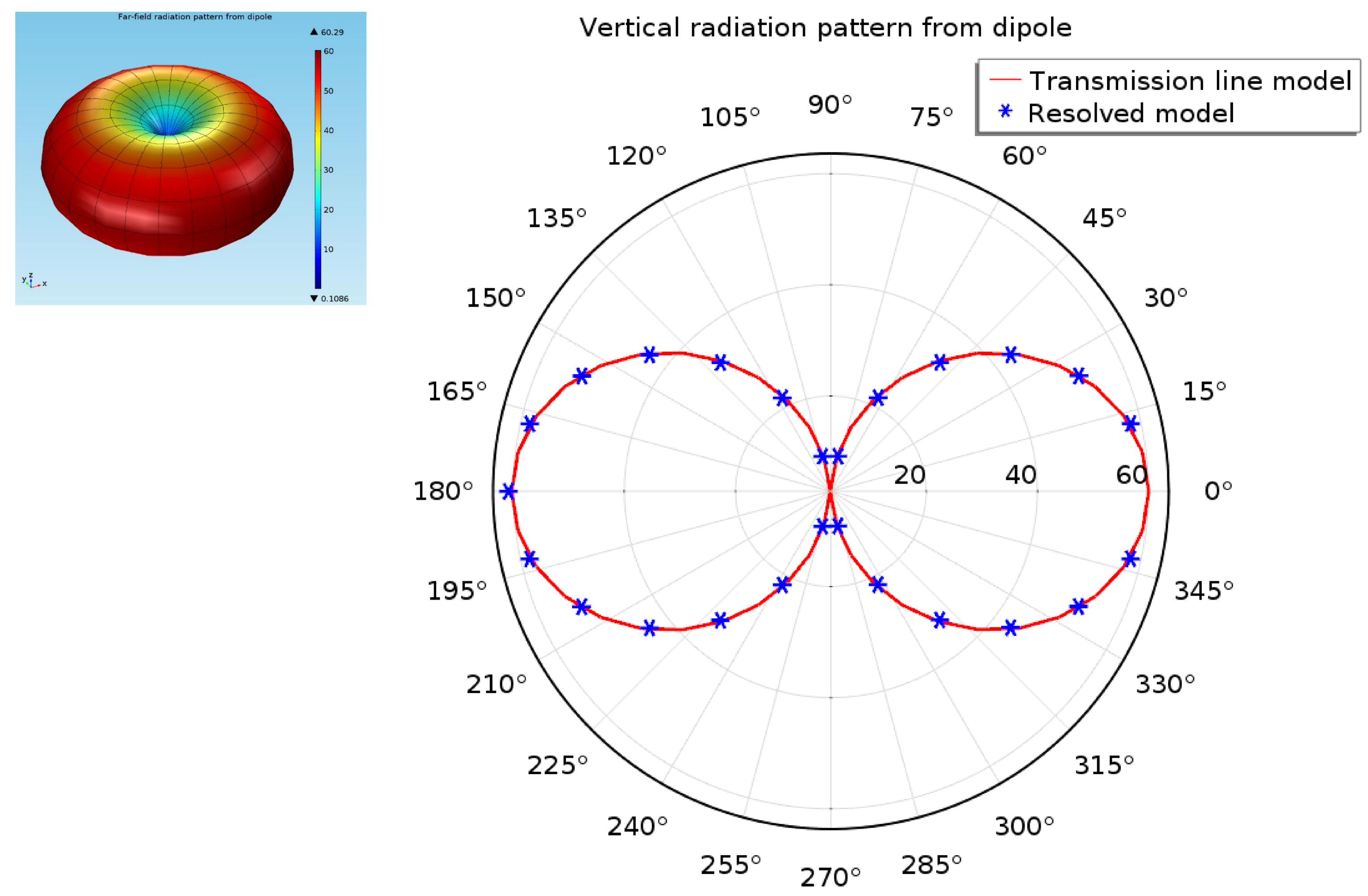

Figure 3. Radiation patterns computed using transmission line model and a resolved cylinder..

Conclusions: Method can prove useful for many kinds of interference studies.

Reference:

1. Taflove, A. and Hagness, S.C., Computational Electrodynamics: The Finite-Difference Time-Domain Method, 3rd ed., Artech House, 2005.