

# Investigating Magnetic and Electric Fields Couplings for 3D Models in Harmonic and Transient States

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## Abstract

At present, no 3D transient magnetic and electric fields formulation with strong eddy currents and high electric fields is available in the physical applications with COMSOL Multiphysics® software. However, some industrial products need such a tool, as it is the case for induction coils of pulsed magnetic technologies. The principle is to induce a force thanks to strong eddy currents induced by a huge pulsed magnetic field. Meanwhile, the terminal contacts of the coil experience a high voltage drop including shorting risks. We suggest investigating one or two ways to perform this physical coupling, thanks to vector and scalar potentials and the definition of physical equations changeable by the users. In order to achieve this goal, we will first try to couple formulations onto a test case with a simple geometry (cylindrical cable portion) and then apply the physical application onto an induction coil example for pulsed magnetic technologies (one turn toroidal coil with a cut).

The aim of this study is to evaluate the faisibility, convergence and reliability of 3D magnetoharmonic and transient formulations coupling the magnetic and the electric fields with eddy currents and high voltage drops. The chosen geometries of the test case and the first example are in fact two dimensional but solved in 3 dimensions in order to both develop and validate the 3D formulation.

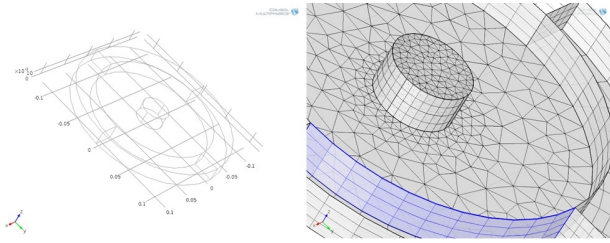
In this work we will propose to:

- explain the geometry and physics of the test case and the coil example,
- introduce some developments of the coupling between magnetic and electric field formulations in steady harmonic and transient states,
- perform and analyse harmonic and transient computations onto the test case:
  - o Draw the scalar and vector potentials, current and flux density profiles,
  - o Extract some global informations, such as energies, equivalent resistance, inductance and capacitance.
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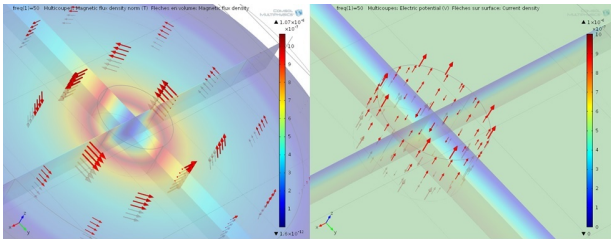
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## Figures used in the abstract



**Figure 1:** 3D geometry (left) and mesh (right) of the first test case.



**Figure 2:** Magnitude of magnetic vector potential and flux density vector (left) Magnitude of electric scalar potential and current density vector (right).