# Numerical Calculation of the Three Dimensional Inter-Bar Current Distribution in Induction Machines

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## Abstract

The calculation of additional losses in induction machines is a challenging task. In skewed motors, a part of these losses is connected to the phenomena of inter-bar currents. Inter-bar currents flow between adjacent bars through the rotor lamination. Since they are aligned perpendicular to bar currents, they cannot be calculated with 2D FEM, where the motor geometry is cut perpendicular to its axial direction.
The proposed numerical model is used to study the influence of inter-bar currents by investigating the three dimensional field solution in COMSOL Multiphysics®.

Since the focus is on the rotor, the whole stator geometry is replaced by surface current densities in terms of Neumann boundary conditions. This includes the winding heads. In a real motor the rotor iron consists of laminated iron sheets. The sheets prevent eddy currents from flowing in axial direction, since the lamination is electrically insulating. The thickness of one sheet is often only about 0.5 mm. This can lead to a rotor package, which carries dozens of sheets, depending on the motors length. Simulating such a detailed rotor with FEM can lead to a very fine mesh. To bypass this, an alternative way of modeling the rotor lamination is presented. The simplifications help to reduce the size and by this also the effort to solve the model. The theory behind them and all needed equations are presented and explained. Different ways to introduce inter-bar resistances are shown, including their advantages and disadvantages.

The model of the motor is described within the "Magnetic Fields" and the "Magnetic and Electrical Fields" interface of the AC/DC Module. The study type is harmonic and the coordinate system is fixed to the rotor.

The results of the model show the influence of inter-bar currents on the distribution of resistive losses in the short circuit cage, in the iron and in the inter-bar resistance regions. Since the motors torque heavily depends on the rotor losses, the torque can be calculated as a function of the inter-bar resistance.
With the chosen approach to respect the rotor stacking, it is possible to investigate the behavior of inter-bar currents for different rotor laminations.

## Figures used in the abstract

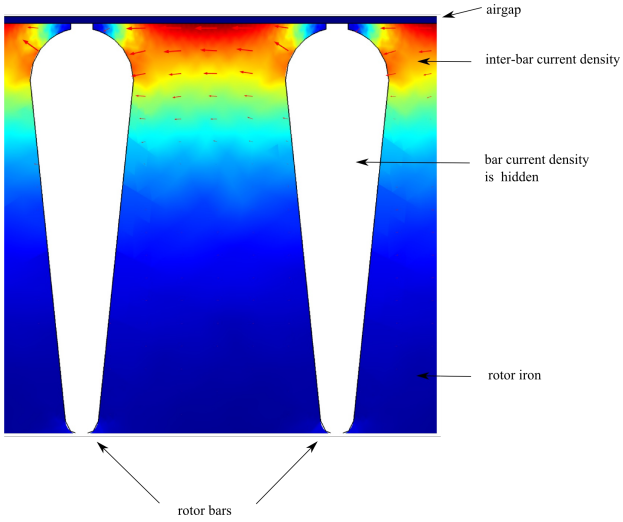


**Figure 1**: Distribution of the current density, which is caused by inter-bar currents in the skewed 3D induction motor.