Brushless Multilayers IPM motor

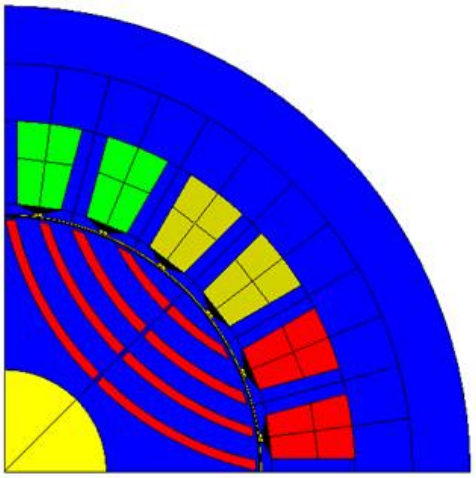
2D Application Note Summary

Introduction

This application note presents the modeling of a Synchronous machine with multilayer's interior permanent magnets with Flux 2D.

Keywords

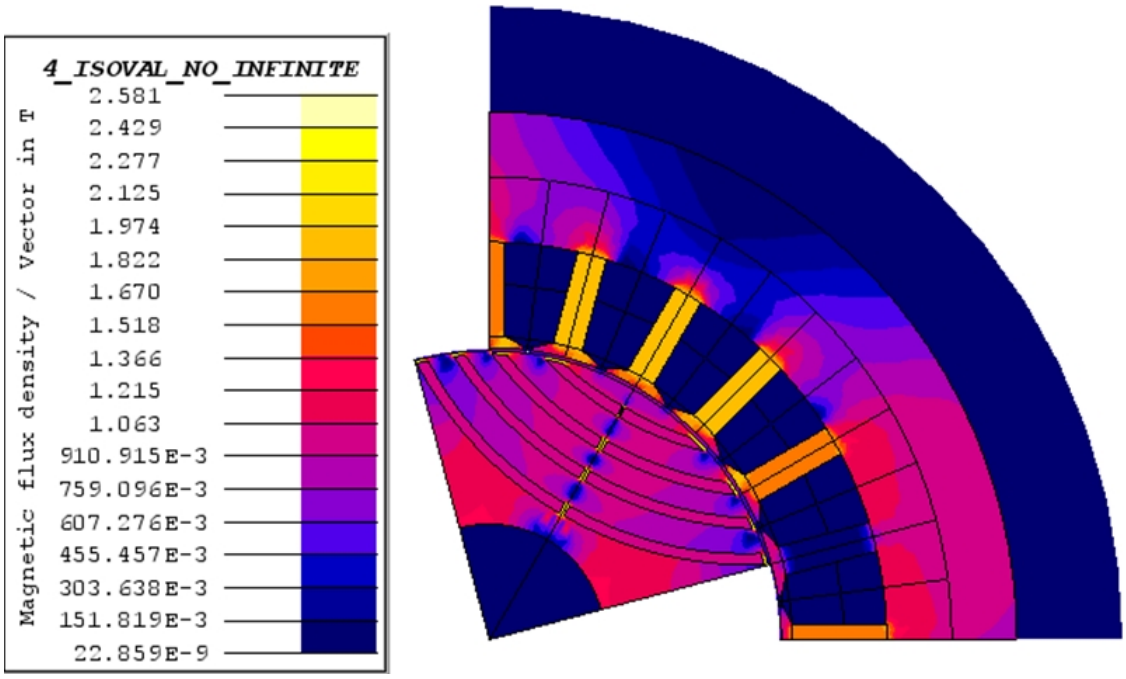
Applications	Flux main functions	Post-processed quantities
• Magneto static • Transient Magnetic	• Sensors • Bertotti loss • Macro • FFT	• Torque, Speed, Position • Back EMF • Current • Flux • Magnetic field • Iron loss • Mechanical power • Efficiency

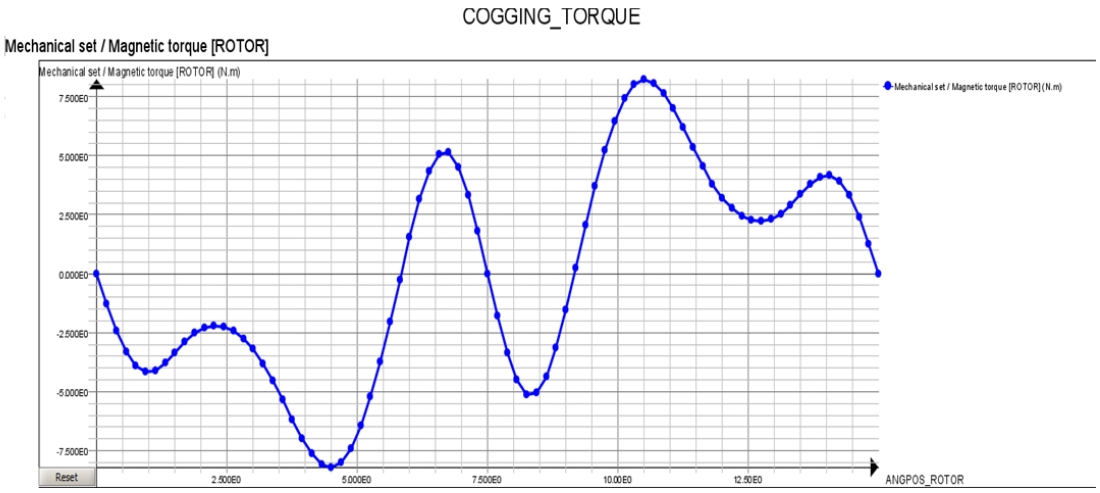
Studied device	
The studied device, a brushless AC multilayers embedded permanent magnets motor presented in the figure below, includes the following elements: • a fixed part (stator) including yoke, slots, and windings • an air gap • a movable part (rotor) with embedded magnets	

Example 1: Multi-position simulation

The cogging torque is computed with a multi-position simulation and no current. The multi-position is simulated with a transient application at constant speed. The speed is chosen to be 1/6 rpm which corresponds to 1 mechanical degree per second.

- Compute and display isovalues of the magnetic flux density on face regions
- Compute and display flux isolines on face regions
- Plot 2D curve of the cogging torque

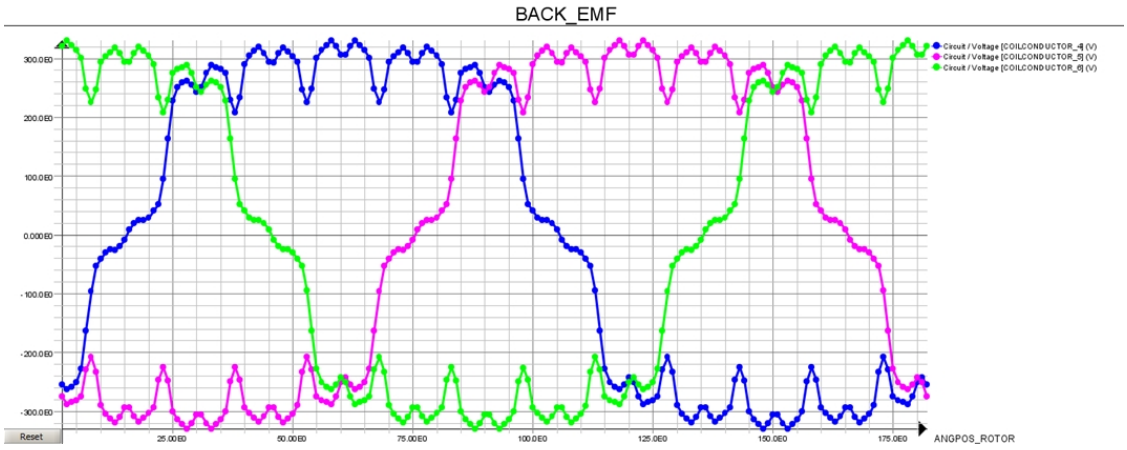


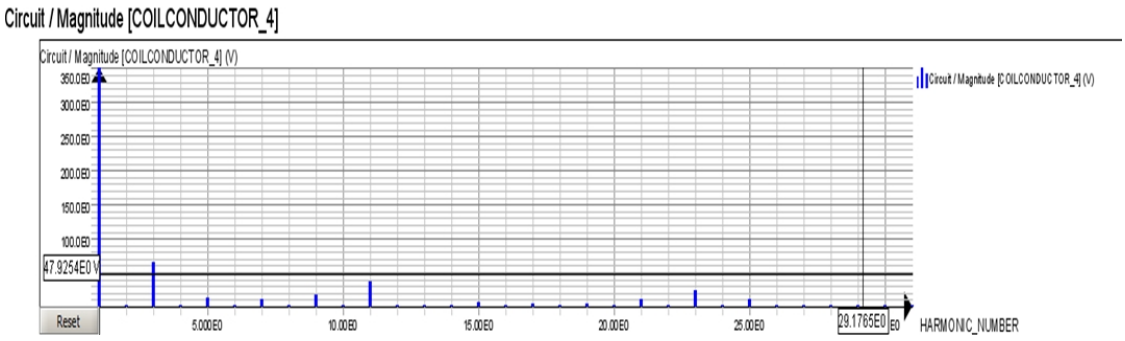


Example 2: Electromotive force

The back electromotive force EMF is computed with the speed of 1200 rpm and external circuit connections. It corresponds to the motor being in generator mode at no load. The computed back EMF allows determining the current control angle.

- Compute and display isovalues of the magnetic flux density on face region
- Plot 2D curve of the voltage through coil conductors according to the angular position of the rotor
- Compute the FFT on the voltage curve through a stranded coil

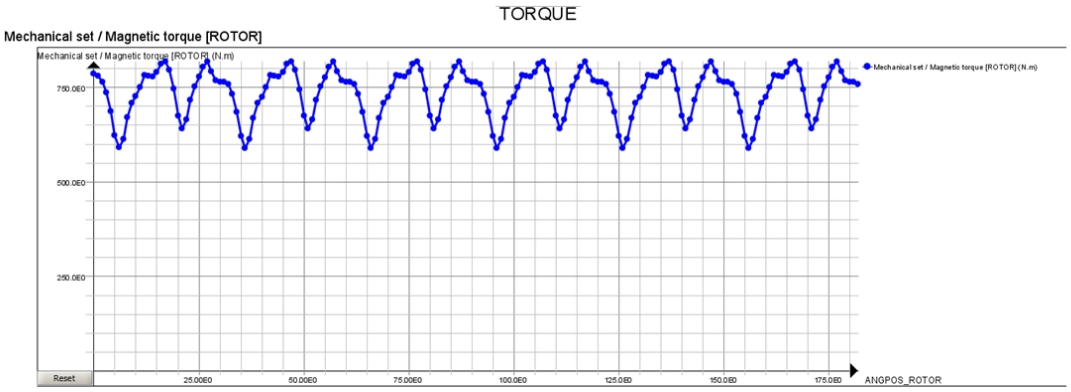




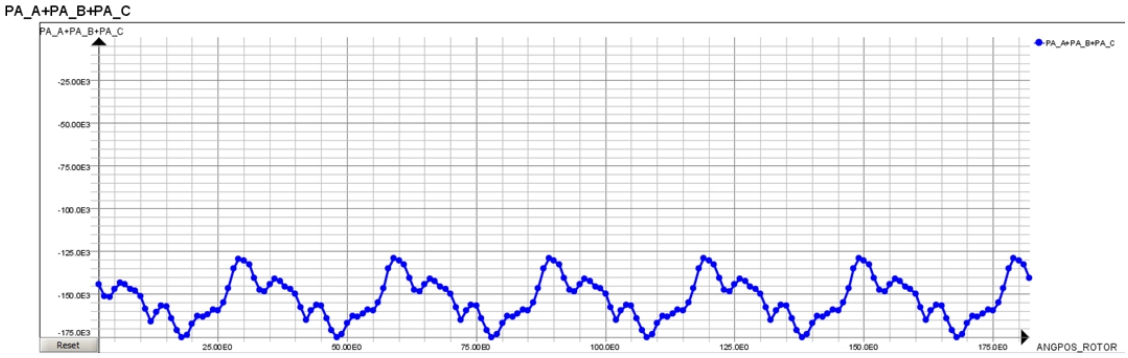
Example 3: Simulated motor performances

The motor is driven with a 3 phase sine current and running at constant speed. The simulated motor performances are used to compute shaft torque, torque ripples, core losses (Bertotti and LS model) and efficiencies. Plot 2D curve of the voltage through coil conductors according to the angular position of the rotor.

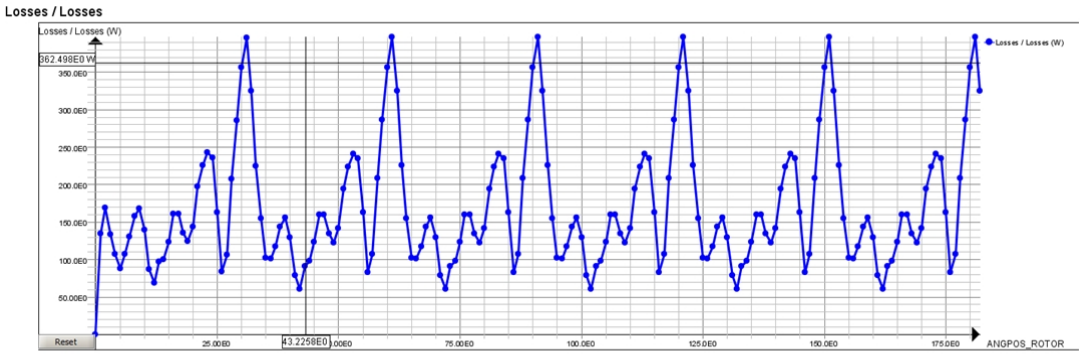
- Compute and display motor torque, LS and Bertotti iron loss on face regions, loss in magnets, input electrical power, mechanical power and then efficiency
- Display isovalues of Bertotti iron loss on face regions



INPUT_ELECTRICAL_POWER



MAGNET_LOSS_1

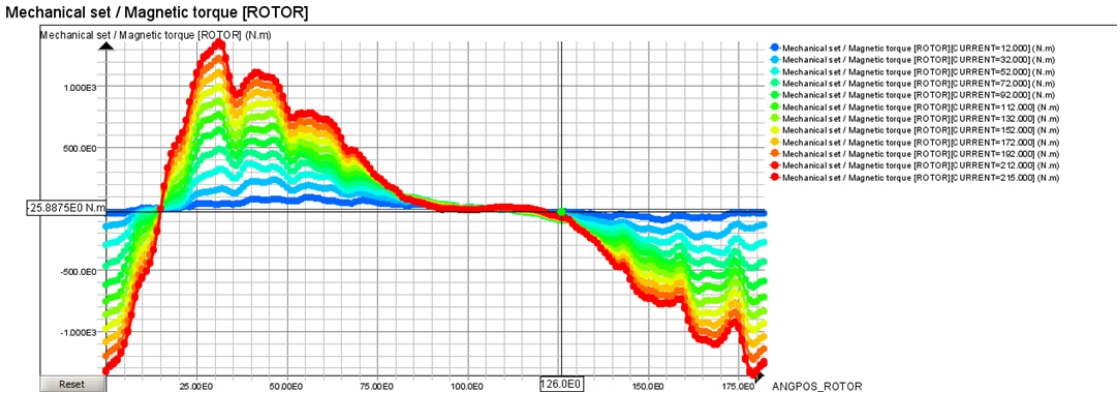


Example 4: Inductances and torque vs. current and rotor position

This simulation consists of computing the inductances and torque vs. current and rotor position.

- Display torque versus position and current
- Display flux versus position and current
- Display incremental inductance versus position and current

TORQUE



FLUX_PHASE_A