



Research topics



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Electromagnetic and smart-materials-based devices

The analysis concerns the development and testing of innovative electromagnetic devices suitable for a wide range of applications:

1. Spherical motors/actuators; MagnetoRheological Fluids (MRFs) - electrodynamics clutches/brakes; fast linear actuators and axial flux devices;
2. Magnetic Levitation and Electromagnetic Launchers;
3. Wireless Power Transfer.

Analytical and numerical techniques for electromagnetic field analysis

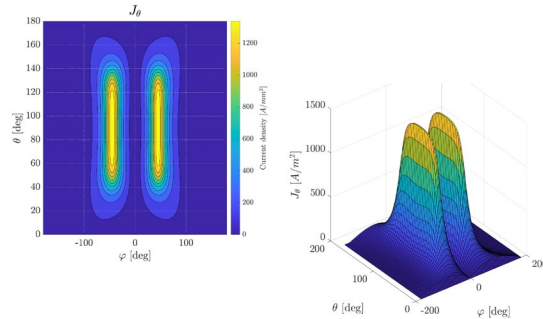
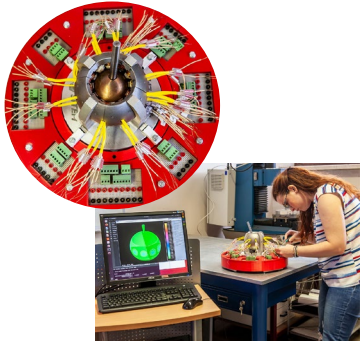
This activity involves the application of analytical and numerical techniques for electromagnetic analysis. Differential formulations (e.g., Finite Element Method (FEM)) are widely used because they allow modeling devices with complex shapes characterized by nonlinear materials. Integral formulations, instead, are used when dealing with problems characterized by several Degrees of Freedom (DoF), high speeds, or sliding contacts.



Electromagnetic and smart-materials-based devices

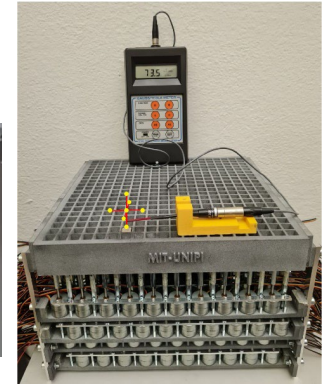
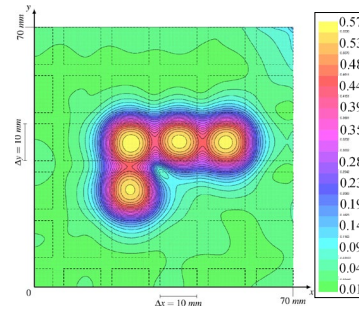
Spherical MRF-based actuator with multi-DoF

Development of a simplified analytical model of the system based on the solution of Maxwell's equations in spherical coordinates, FEM simulations with a full-3D model, and experimental validation to assess the performance from both electrical and mechanical perspectives.



Haptic interfaces based on MRF

Simulation of the magnetic behavior of an MRFs-based haptic device using finite element (FE) models to verify the performance of the device in creating shapes with variable compliance that can be perceived freely through manual exploration.



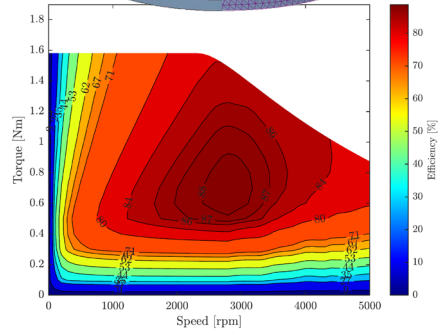
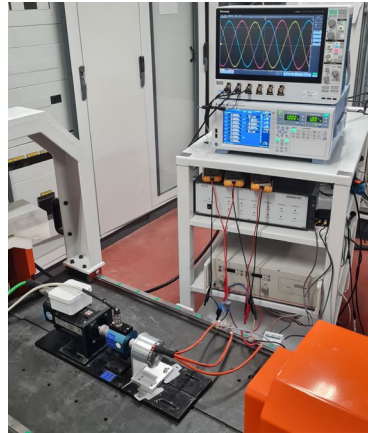
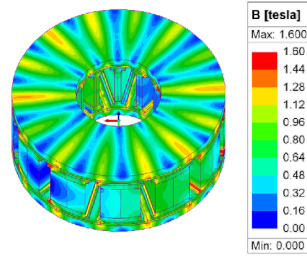
C. Simonelli et al., "Development of an Innovative Magnetorheological Fluids-based Haptic Device Excited by Permanent Magnets," 2021 IEEE World Haptics Conference (WHC).



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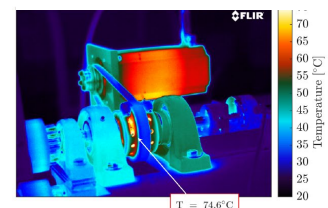
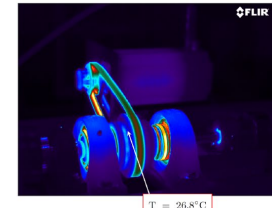
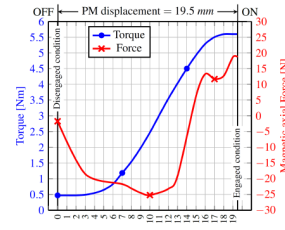
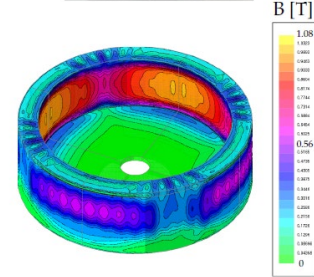
Axial flux devices

Design and test of axial flux electromagnetic devices for automotive applications.



MRF electrodynamic clutches

Investigation of the performance of the device with FE simulations and experimental test applying the standardized WLTC conditions to assess the operation of the MRF-clutch in coupling/decoupling the vacuum pump from the camshaft.



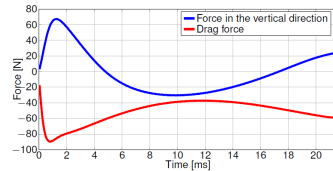
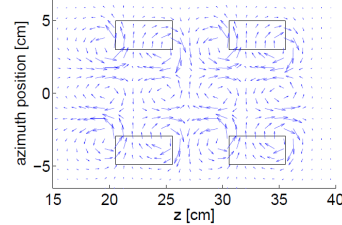
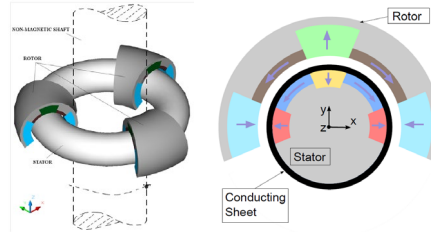
C. Simonelli et al., "Experimental Validation of a Permanent Magnets MagnetoRheological Device under a Standardized WLT Cycle", Actuators 12, 2023, no. 10: 375.



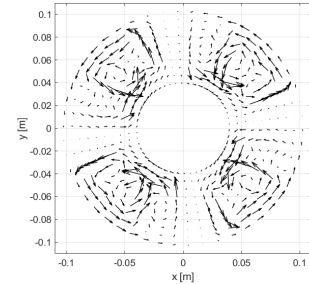
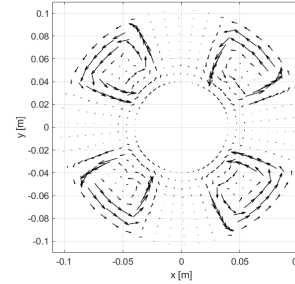
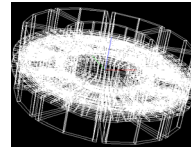
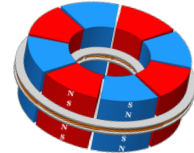
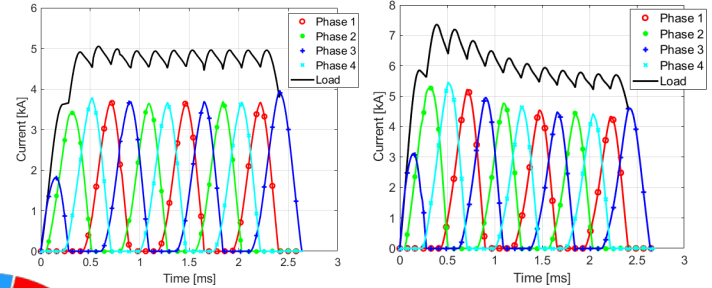
Analytical and numerical techniques for electromagnetic field analysis

Simulation of complex electromagnetic devices using an equivalent network approach, where the integral formulation of the magnetic diffusion equations with moving conductors enables the derivation of a set of equilibrium equations of a time-varying electric network.

Magnetic bearings



Air-core axial flux pulsed alternator



C. Simonelli et al., "Electromagnetic Analysis of an Axial Flux Air-Core Compulsator", 2024 10th EAPPC-BEAMS-EML 2024.