Design of an Electrodynamic Levitation System with COMSOL Multiphysics® Software

H. P. Ferreira[1], A. Endalecio[1], E. Rodriguez[1], R. M. Stephan[1]

[1]Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Abstract

1. Introduction
The levitation phenomena have found important applications in several areas of engineering, from microgravity to transportation systems [1]. An important technique of levitation is the electrodynamic.

The electrodynamic levitation consists on the interaction of a varying in time magnetic field - provided by an alternating voltage supplying a coil or a moving permanent magnet, for example - and the induced magnetic field generated in a conducting material, like copper or aluminum, producing a force that counterbalances the weight [2]. The main applications of this technique are MagLev trains and magnetic bearings.

The electrodynamic experimental system, presented in Figure 1, was developed at Universidade Federal do Rio de Janeiro (UFRJ) with objective of achieve suspension of two conductor rings - aluminum and copper - supplying alternate voltage at a coil with grid voltage of 127 Vrms. The COMSOL Multiphysics® software was used to provide the system configuration solution.

2. COMSOL Multiphysics Use
COMSOL Multiphysics has many features in the Electromagnetics area. The AC/DC Module was appropriately chosen for study the magnetic levitation phenomenon with its Magnetic Fields physics interface [3].

In the developed model, the geometry was generated using the 2D Axisymmetric. The conductor rings materials were predefined with the Material Library. In the iron core was applied Ampère's Law and the coil was defined using the Multi-Turn Coil Domain. The induced magnetic field and the electromagnetic force produced in both rings were analyzed. The study was performed in the Frequency Domain. The finite elements mesh of the model is shown in Figure 2.

The preliminary experimental results were compared with the study model for validation. The following step was modify parameters like, number of turns, cross section area of the coil wire, rings dimensions and electrical frequency of applied voltage, to achieve the desired solution.

3. Results
The results of the computational model showed that the conductor rings could levitate at the

desired 127 Vrms for a coil's supplied voltage frequency of 15 Hz. Experimental tests at laboratory confirmed the COMSOL solution, how can be seen in Figures 3 and 4.

4. Conclusion

This work presents a magnetic levitation experiment that could be used as an introduction of undergraduate students in the research of mechatronic systems. In this area, the simulation tools are an indispensable part on analysis and design, saving time and costs.

The COMSOL Multiphysics software provides a friendly user's interface and a powerful tool in analysis of magnetic levitation systems showing its magnitude in the design of electromagnetics systems.

Reference

[1] Brandt, E. H., Levitation in Physics, Science, Vol. 243, no. 4889, pp. 349-355, January 1989.

[2] Jayawant, B. V., Electromagnetic Suspension and Levitation, IEE Proceedings A, Vol. 129, Issue 8, pp. 549-581, November 1982.

[3] AC/DC Module User's Guide, COMSOL Multiphysics version 4.3.

Figures used in the abstract

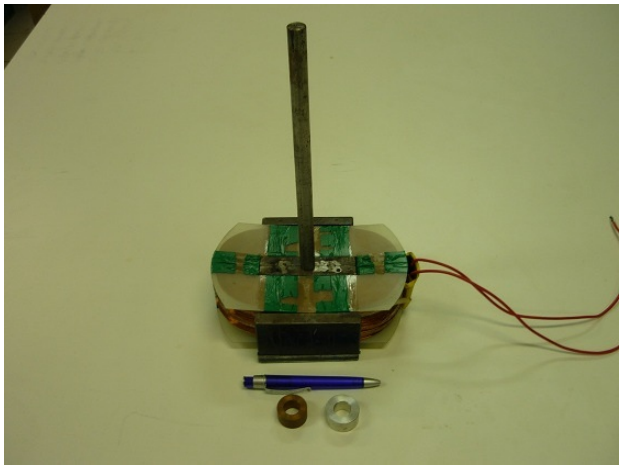

Figure 1: Electrodynamic levitation system and metallic rings: copper (left) and aluminum (right).

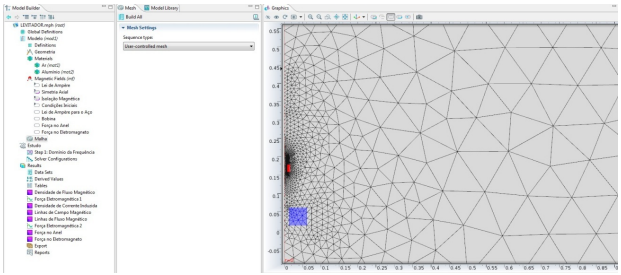

Figure 2: Finite elements mesh generated in COMSOL Multiphysics and its interface.

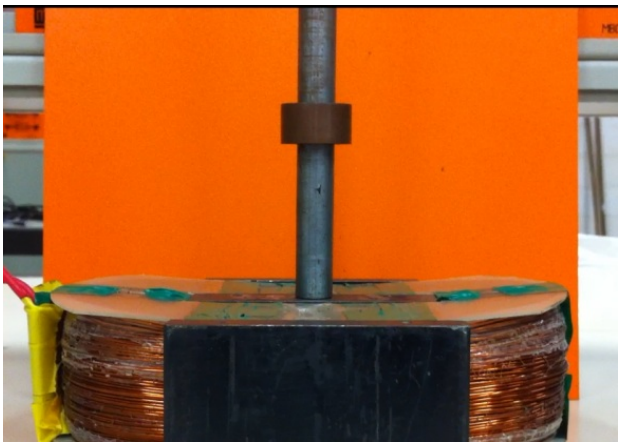

Figure 3: Levitation of copper ring at 127 V and 15 Hz.

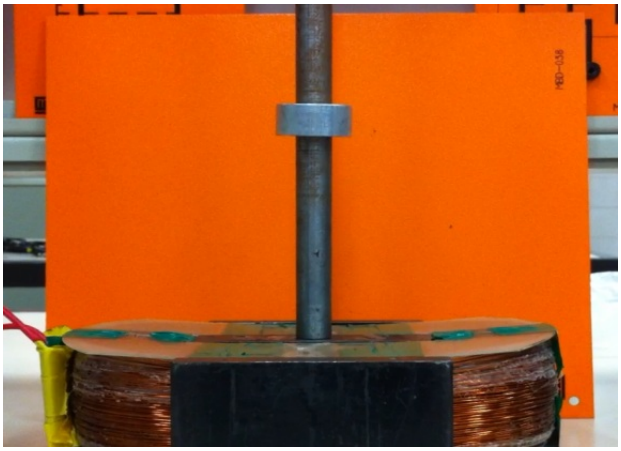

Figure 4: Levitation of aluminum ring at 127 V and 15 Hz.