Effect of Linear and Non-linear Electromechanical Coupling in Magnetic Levitation Energy Harvester

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Abstract. The paper focuses on analysis an effect of the electromechanical coupling (EC) in a magnetic levitation energy harvesting (EH) system. The new nonlinear EC model including the position of moving magnet vs. coil terminal is proposed. The model was applied in magnetic levitation harvester. An experimental study is conducted to validate the simulation results.

Introduction

Energy harvesters are mechanism that generally convert ambient energy into usable electrical energy. Apart from the obvious sources such as solar and wind energy, there are other energy sources that can be widely used. One such source is fairly ubiquitous mechanical vibrations which are potential source for energy harvesting for low power applications such as micro-sensors or sensor nodes. The vibration harvesters using a magnetic levitation effect are wide used in practice due of its simplicity, lack of springs and dampers and long time of usage. However, the electromechanical coupling modeling is one the main problem in such systems.

Energy harvesting system modelling

The single levitating harvester in Figure 1(a) is presented. It consists of the cylindrical non-magnetic tube with the two fixed permanent magnets, the cylindrical moving (magnetic levitating) magnet and the coil terminal. The magnet moving axially through the center of a coil will induce a voltage across the coil terminal. The harvester can be modeled as the nonlinear spring-mass damper system with an external base excitation, connected to the electrical circuit (Figure 1(b)).

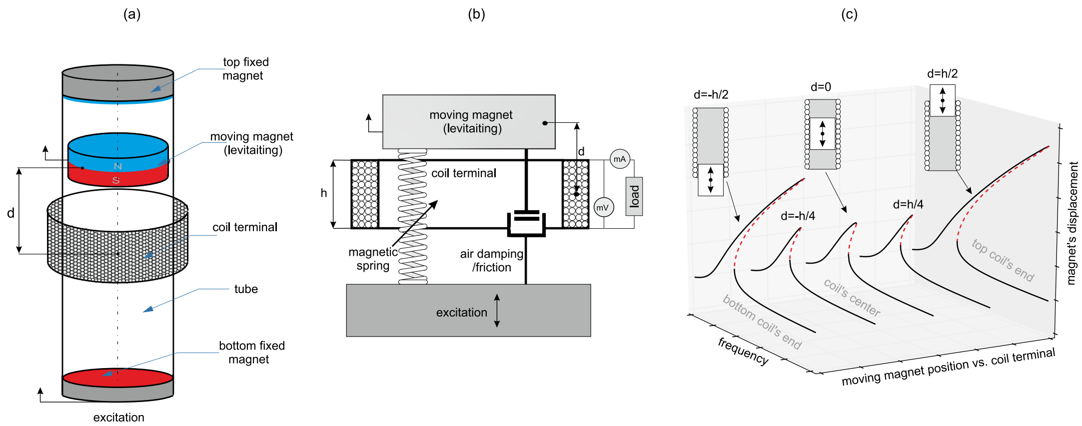

Figure 1: Scheme of single levitating vibration energy harvester (a), the physical model (b) and resonance responses (c).

Problem formulation

The electromechanical coupling parameter characterizes how the induced voltage in the coil is related to the velocity of the magnet and depends on the magnet-coil configuration. EC can be treated as the linear function especially for small oscillations. However, for high oscillation and for case when the moving magnet can leave the coil terminal, the linear model is insufficient. In the paper we propose the new nonlinear model of the EC dedicated for small and high oscillation of the magnet. The model includes the moving magnet position vs. the coil terminal (parameter d in Figure 1). The obtained results show that parameter d strongly influences the dynamics (Figure 1(c)) and EH. This suggest that simply configuration of the magnet and coil terminal can be used for optimization of recovered energy.

Acknowledgements

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