A numerical study of an autoparametric system with added electromagnetic energy harvester

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Abstract
This paper presents an electromagnetic energy harvester mounted inside the pendulum construction to generate energy. The total system consists of three coupled subsystems (Figure 1). The first is a linear oscillator (main object). The oscillator is suspended on a linear spring (k_1) and linear damper (c). The motion of main object is described by the vertically displacement *x*. The vibrations of this element are caused by kinematic periodic excitation *y*. To reduce vibration of the main part, a nonlinear absorber (pendulum) is added [3]. Its motion is described by the coordinate φ, which represents an angular displacement of the pendulum. In such system, pendulum can perform different types of responses [1], for example: fixed position in the upper or lower position (I), rotation (II), swinging (III) or different forms of chaotic motion (IV). In paper [2] revolute joint to connected energy harvester and pendulum was presented. This application gives good results when the pendulum rotates or performs chaotic motion. However, in this case, vibration reduction and control by the damping of the pendulum is difficult. The third subsystem is a harvester device mounted inside the pendulum. This electromagnetic energy harvester consists of a magnet and coil (Figure 2). The suspension of the magnet is realized by linear spring (k_3). Motion of the magnet is described by the coordinate *r*, which depends on electromagnetic properties of harvester and dynamics of the pendulum-oscillator. The total construction has three degree of freedom, and additionally all subsystems are inertial coupled. We can see the electrical circuit of coil, which was used to determine the produced power [4]. When the magnet is moving then is induced a voltage, a current *i* flows through the circuit.

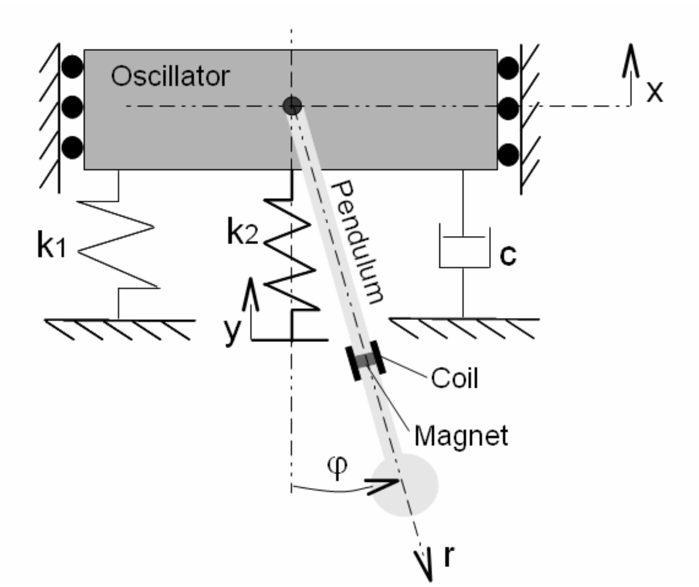

Figure 1: Scheme of an autoparametric system with energy harvester.

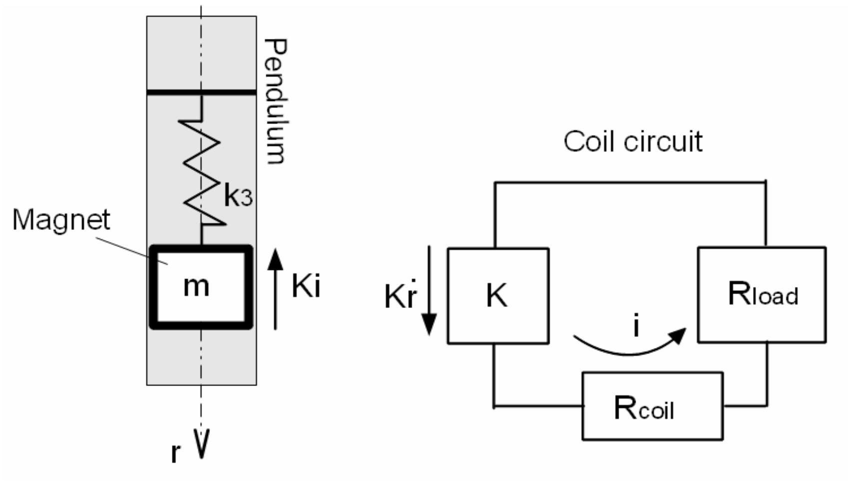

Figure 2: An electromagnetic energy harvester and electrical circuit.

The proposed construction of electromagnetic energy harvester can be used to energy harvesting from pendulum swings. Then, it is possible to obtain two effects at the same time: vibration reduction and energy recovery. The parameters for first and second subsystems were estimated from experimental research of the laboratory rig. The numerical analysis was used to determine the optimal values of parameters of electromagnetic energy harvester. The topological optimization in Matlab software was made. The work is a first step of analysis of the proposed conception. The main aim of this work is to determine of system parameters for which the magnet vibrates and generate voltage. Moreover, the real construction of the harvester in future will be prepared based on the numerical results.

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