Design and Optimization of Electromechanical Coupling in Electromagnetic Vibrational Harvester

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Abstract. In this study, electromechanical coupling is used to optimize and change the performance of an electromechanical harvester. The obtained results demonstrated that the electromechanical coupling is inherently nonlinear and can introduce new resonances. The special design of coils and/or magnet allows for the modification of the shape of electromechanical coupling, resulting in an increased energy harvesting. The experimental determined electromechanical coupling model were compared to finite element analysis results. Finally, the shaker test was performed for different electromechanical transducer configurations.

Introduction

An electromechanical coupling is a measure of the conversion efficiency between electrical and vibration energy The main disadvantage of electromagnetic harvesters is its low efficiency, which is caused by low vibration levels and weak sensitivity outside the resonance region [1]. The motivation of the paper is maximizing electromagnetic energy harvester effectiveness without increasing harvester's size. The autoparametric vibration absorber, which is extremely sensitive to the system's parameters, uses the proposed harvester as the pendulum tuned mass damper [2].

Results and discussion

The vibrational electromechanical harvester generally consists of the magnet oscillating in the coil. The effectiveness of harvester depends on the interaction between mechanical and electrical systems. This interaction is referred as the as *electromechanical coupling* or *transduction factor*. The modification of the coupling can improve energy harvesting without change in the transducer design. The two method of the electromechanical coupling shaping is applied here. First method for shaping of the electromechanical coupling based on the modification of the coil. The coil (called modular) consist of four separate independent coils (modules) which can be connected in various way. Each of the modules can be activated separately or together (for example, modules no. 1 and 4 can be activated). Moreover, the different shape (C, L) of the modular coil are constructed and tested (Fig.1(a)).

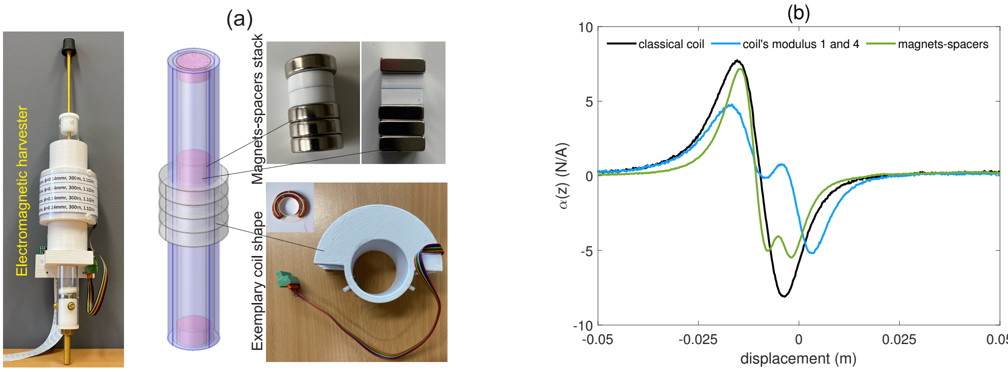

Figure 1: Electromagnetic vibration harvester (a) and exemplary shaped electromechanical coupling functions (b).

The second method is based on an oscillating magnet that has been specially designed. The magnet can have a different shape (circular or rectangle) and/or consists of stacked magnets and spacers (repulsive or attractive orientation).

The electromechanical coupling functions obtained for the coil with the active two modules 1 and 4 (blue line) and for the specially built asymmetric magnet (green line) vs magnet position in the coil are shown in Fig.1(b). As we can see, these functions differ from the typical electromechanical coupling (black line). Therefore, we expected, that the proper configuration of the magnet-coil allows increase effectiveness of energy harvesting.

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References

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