Modeling of Piezoelectric Transducers Made of PZT for Energy Harvesting

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Abstract

This work shows the results of modeling of piezoelectric transducers used to recover energy from mechanical vibrations. The analysis consists of usefulness of commercial ceramic PZT transducers to power electronic systems. Determined output load characteristics, characteristics of the effect of stress on the output power were compared with the experimental data.
Systems, which recover electrical energy for example from mechanical energy vibrations are increasingly applied to power sensors and measurement setups[1]. Piezoelectric transducers based on materials like PZT or PVDF are well suited for this purpose. The simple and cheap construction of transducers based on ceramics PZT can be effectively used to recover energy from mechanical vibrations[2, 3]. This work shows the applicability of COMSOL Multiphysics environment to model and simulate transducers in various operating conditions. Fig. 1 shows the construction of the station with piezoelectric transducer and electromagnetic coil used to force vibrations.

Fig.1 Schematic of the construction with PZT transducer
As a result of modeling and simulations characteristics of output power have been received for commercial PZT-4 transducer working in resonance conditions. The dimensions for the bronze membrane were: the diameter - 35 mm and the thickness - 0.25 mm, while in case of the PZT-4 element - 25 mm and 0.22 mm, respectively. The diameter of the silver layer was equal to 19 mm and its thickness was 0.05 mm. In case of magnets, it was adequately 10 mm and 5 mm. The material parameters of PZT-4 were taken into account from the COMSOL material library. Parameters of other materials were taken from the website matweb.com. The resonance frequency for fixed constraint (as in Fig.1) was 1927.8 Hz.

Fig.2 Characteristics of the output power depending on the load current for different F forces
Characteristics of the output power for different loads and forces affecting the transducer are shown in Fig.3.

Fig.3 Characteristics of output power depending on force for different I1 loads

The results of modeling shows, that it is possible to use cheap commercial transducers based on PZT to power electronic systems, for example measurement ones. Maximum values of the

power were reached in resonance conditions (basic mode). The values of the power depend on constraint conditions. Maximum power rises with the increase of the vibration frequency and the mass of piezoelectric. Experimental results vary from the results of modeling, which is caused by the inaccuracy of parameters given by producer (the tolerance is about 20%) and troubles in fulfillment of boundary conditions during the experiment.

Reference

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Figures used in the abstract

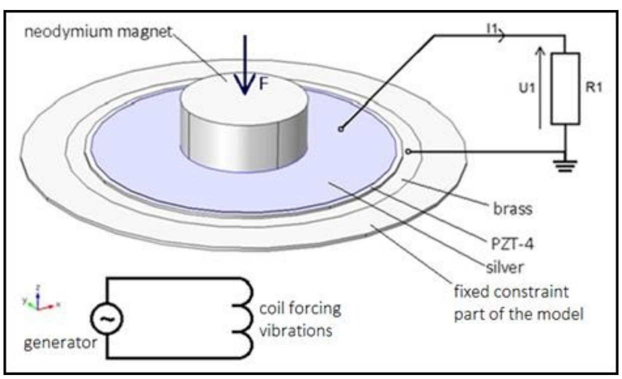

Figure 1: Fig.1 Schematic of the construction with PZT transducer

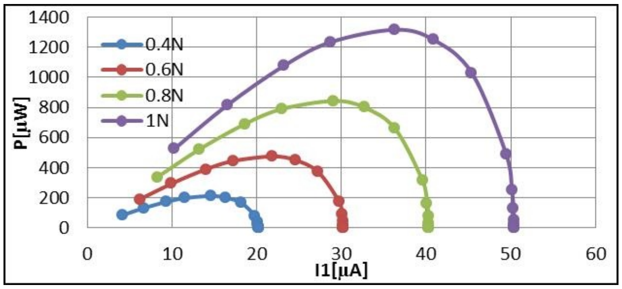

Figure 2: Fig.2 Characteristics of the output power depending on the load current for different F forces

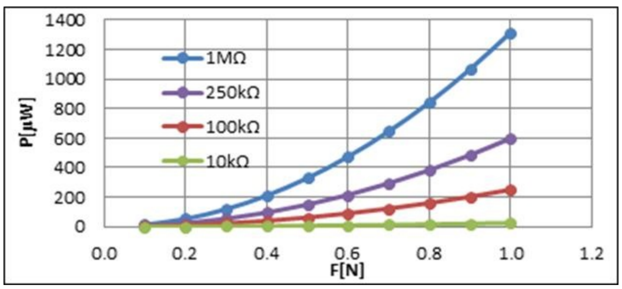

Figure 3: Fig.3 Characteristics of output power depending on force for different I1 loads

Figure 4