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Magnetic circuit modifications in resonant vibration harvesters

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ABSTRACT

The paper discusses the conclusions obtained from a research centered on a vibration-powered milli- or micro generator (MG) operating as a harvester to yield the maximum amount of energy transferred by the vibration of an independent system. The investigation expands on the results proposed within papers that theoretically define the properties characterizing the basic configurations of a generator based on applied Faraday's law of induction. We compared two basic principles of circuit closing in a magnetic circuit that, fully or partially, utilizes a ferromagnetic material, and a large number of generator design solutions were examined and tested. In the given context, the article brings a compact survey of the rules facilitating energy transformation and the designing of harvesters.

1. Introduction

The current search for alternative sources of energy (namely, its residual or otherwise unusable forms) has become the subject of multiple research reports and monographs [1–10] that apply the principle of converting one form of energy to another, utilizing resonance to improve the energy transformation ratio. Selected physical principles of conversion are shown in Fig. 1, and they can be classified into the following categories:

– Piezoelectric effect (electro-striction);
– Magnetostriction effect;
– Faraday's electromagnetic effect;
– Thermoelectric (Petlier, Seebeck effect);
– Electrostatic effect (capacitance);
– Pyroelectric effect;
– Chemical-ion electromagnetic field generation;
– Combined photoelectric effect.

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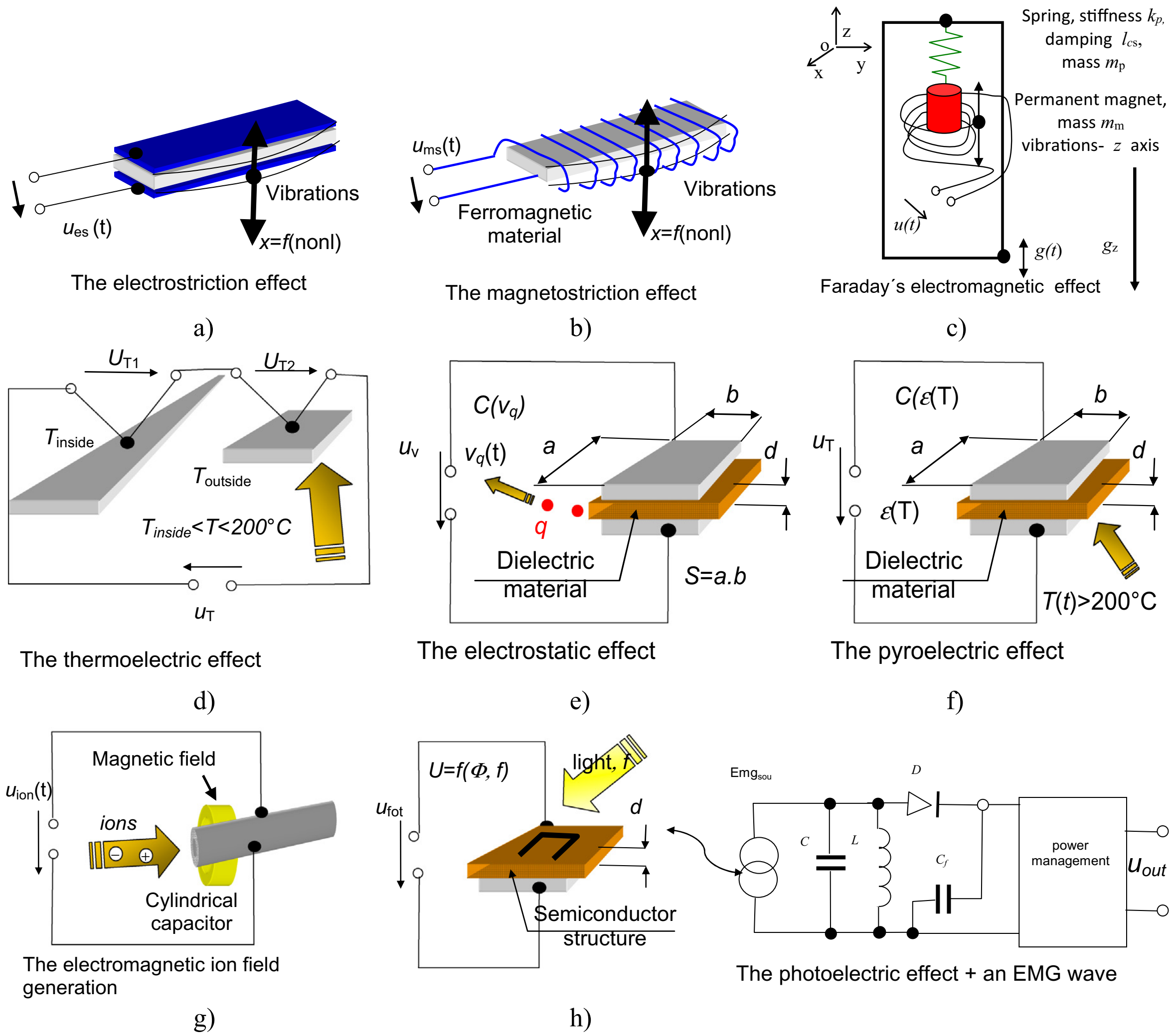

Fig. 1. The principles of energy harvesting: (a) the electrostriction effect; (b) the magnetostriction effect; (c) Faraday's electromagnetic effect; (d) the thermoelectric effect; (e) the electrostatic effect; (f) the pyroelectric effect; (g) the generation of a moving electromagnetic ion field (EMHD generator); (h) the photoelectric effect and an EMG wave harvester [13].

A viable method appears to consist in extracting the residual energy produced by the vibrations of the autonomous structure on which the relevant harvesting device is seated and adjusted for operation. The technique finds use within fields such as transportation or communications, in equipment required to provide a higher degree of reliability and error-free functioning. In electrical and electronic systems, by extension, the entire process regulation chain has to be supported by dependable feeding of the sensors and effective transfer of information from a sensor to another processing component. One of the approaches to increasing the reliability of sensors consists in supplying energy from autonomous power sources; for example, sensors used in automotive systems can be located at critical points, without supply and data transmission systems. These sensors monitor significant quantities during the operation of the system. When performing the actual monitoring and revision steps, the operator merely scans the device being tested and uses wireless transmission to acquire the needed data from all sensors. These data can then be compared with those from a previous system cycle or with any other information available.

Vibration harvesters operating with variable magnetic fields were outlined within report [2], which theoretically defines the properties characterizing the basic configurations of a generator based on applied Faraday's law of induction [1]. A large number of design solutions were compared and tested [2,3].

As part of project 6FP EU – Wireless Sensing (WISE), the authors of the present article participated in applied research centered on wireless technologies in aeronautics, collaborating with partners on the effort to find an effective and robust method for feeding the electronic circuits located in uneasily accessible or extreme sectors of aircraft. Assuming available techniques and relevant conditions in individual parts of the given aricraft, the possibilities of residual energy harvesting were evaluated and summarized (Fig. 1). Based on a comparison of the harvesting principles illustrated in the figure, and