JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS Vol. 13, 2011

Piezoelectric microgenerators for body energy harvesting

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In the Department of Micro and Nano Electrotechnologies (DMNE) was approached by the “energy harvesting (harvesting)” which included a piezoelectric microgenerators (type harvesting) and representing the collection or recovery of energy from the environment and conversion of mechanical energy, acoustic, chemical to electrical energy. Piezolectric microgenerators (type harvesting) is used to power wireless microsensors used for monitoring resistance systems in buildings, or physiological and environmental parameters.

(Received May 04, 2011, accepted May 11, 2011)

Keywords: Microgenerators piezoelectric, Energy harvesting, Power wireless sensors

1. Introduction

A piezoelectric material has the ability to convert electrical energy into mechanical energy of deformation (inverse piezoelectric effect-actuator), and also to transform mechanical strain energy into electrical charge (direct piezoelectric effect [1,2,3]

Piezoelectric transducers are a promising choice for utilizing the vibrations for energy harvesting[3,4,5].

Microfabricated electric microgenerators , scavenging ambient mechanical energy , are potential power sources for autonomous systems [6,7]

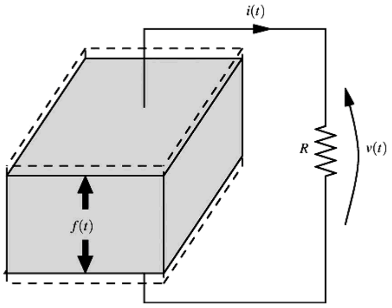


Fig.1. The piezoelectric harvesting functional principle.

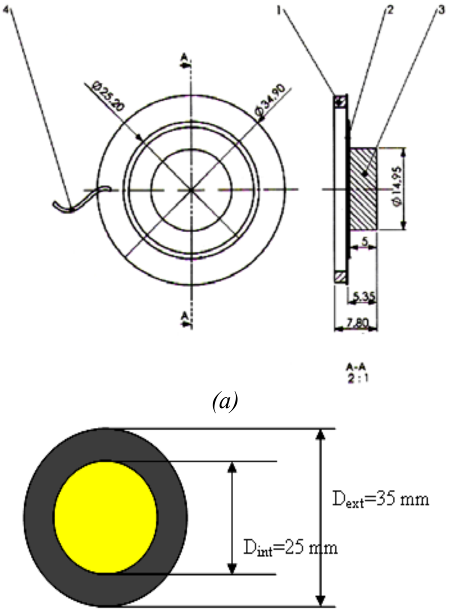
The principle of harvesting energy from vibration using piezoelectric materials is illustrated in Fig. 1. The chain begins with a conversion of mechanical energy source: the vibrations are converted into electricity by piezoelectric. The electricity produced is then rectified with a static converter before providing a storage system or task (electrical device load).

For the piezoelectric conversion , a step down transformer and a regular are necessary for conditioning and adaptingthe generator high piezo voltage to the application voltage level.

In this study, before developing piezoelectric micro-generators, was essential to begin a study to identify sources of mechanical vibration which means faster performance and frequencies of vibration measurement and analysis. So, we made measurements at different frequencies of vibration in the experimental to identify how energy harvesting is the most efficient possible. We could then develop a piezoelectric generator adapted to a natural way of vibration encountered in the environment.

2. The microstructure of a piezoelectric microgenerator

In Fig. 2 is presented a microstructure of an harvesting piezoelectric generator.The structure includes a disc support with an approximate diameter by 35 mm and a piezoelectric disc with ~ 25 mm and a thickness of 0,2 mm by PZT5.

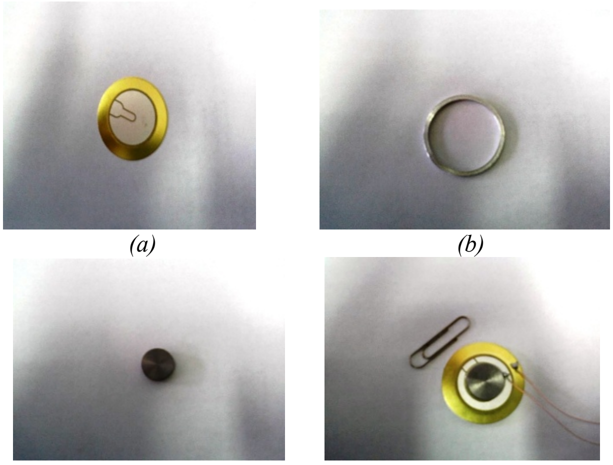


(a)

(b)

Fig. 2. The structure of a micropiezoelectric harvesting: (a) The geometry and the dimensions; (b) The representation of the microgenerator.

In Fig. 3 are presented the component of microstructure of microharvesting generator.



(c) (d)

Fig. 3 .The component of structure piezoelectric microgenerator (type harvesting) µPH - 1: (a) piezoelectric disc; (b) annular frame; (c) inertial mas s; (d) piezoelectric generator assembly (viewfrom top).

3. The theoretical aspects

The model of this piezoelectric microgenerator is based on the electromechanical analogies[1,4,5] and will provide a modal one degree of freedom. In paper we use the analogy where F(force)$\propto U$ (voltage), and x(coordinate)$\propto q$ (electric charge).The mechanical conversion(see Fig.4), can be represented, using the parameter $m -$ for modal mass(in our case the inertial mass), $c_m -$ the modal stiffness, $d_m -$ the modal damping,$C_p -$ the piezoelectric capacity,$R_{load} -$ the resistive load of the driven application, and the transmission factor $\alpha -$ leads to the derivation of the equations of motion :

$$c_m\left(x(t)-y(t)\right)+d_m\left(\dot{x}(t)-\dot{y}(t)\right)+m\ddot{x}(t)=-\alpha F(t) \quad (1)$$

$$c_p\left(\alpha(t)-q(t)\right)=F(t) \quad (2)$$

$$R_{load}\dot{q}(t)=F(t) \quad (3)$$

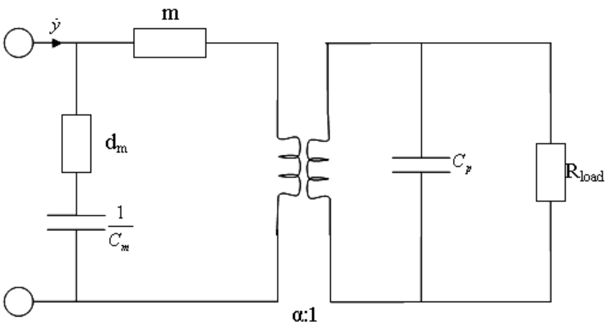


Fig.4. The conversion model.

The transfer functios for the generated voltage and for the microload power can be written in the Laplace space:

$$U(s)=$$

$$=\frac{[(c]_m+d_m s)\alpha R_{load}v_{base}}{sR_{load}\alpha^2+[c_m+s(d_m+ms)](1+sC_pR_{load})} \quad (4)$$

$$P(s)=U(s)\left(\frac{U(s)}{R_{load}}\right) \quad (5)$$

4. The experimental aspects

We realised different experiments specific to the human body. In Fig.5 is showed an experimental specific human body energy harvesting.

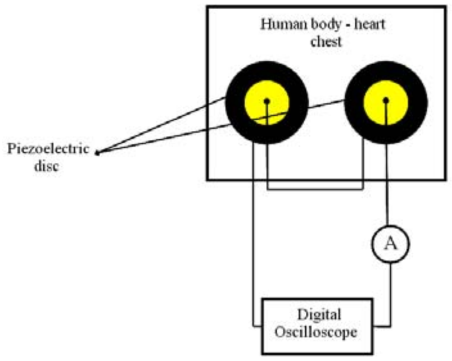


Fig. 5. The specific experimental scheme.

In Fig. 6 is also an experimental mounting for vibration standardization of the harvesting microgenerator.

Fig. 6. SHOP MODE system for creating vibrations that operates in frequency range: 5Hz - 1kHz.

Table 1 presents the voltage the electric current and the micropower specific to different body parts: heart rhythm, respiration, cough and spoken and in Fig. 7 and 8 specific signal voltage for cough and breathing.

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