Studied and Modelisation of a New Type of Piezoelectric Transformer Using Piezopolymer

G. Terziev[1], Ph. Benech[2]

[1]*INRNE, Sofia, Bulgaria*

[2]*IMEP, Grenoble, France*

Abstract

Piezopolymer of the PVDF family are nowadays well known for their properties and possible use in different applications particularly for sensors and actuators realization. Losses in such materials are more important than in ceramic like PZT. However, this material presents some interesting figure of merit. So we have studied the possibility of using this material to realize a piezoelectric transformer. The first transformer was proposed by Rosen in the 50th and was dedicated to ceramic materials. The structure proposed by Rosen was based on the classical transformer structure: on primary and one secondary. For the electrical point of view, the voltage change between primary and secondary was based on the ratio of the capacitor of each part. For the acoustical point of view, the primary is exited in thickness mode and the secondary is used in transverse mode. The dimensions of the piezoelectric bar determine the frequency of operation. Later study derived from Rosen structure was studied using different vibrational modes or multi-layer structure. The efficiency of the transformer is greatly dependent on the losses of the material. So if the Rosen type transformer is used with polymer material, it results in bad voltage transformation ratio, and it is impossible to increased the input voltage at the secondary electrodes. The interest of piezoelectric transformer is greater actually, and the applications are principally where the classical electromagnetic transformer cannot be used: in environment with high magnetic field, in low dimensions - typical conditions in the detectors used in particle physics.

We have studied a new structure of piezoelectric transformer, more suitable to Piezopolymer material. The basic principle is to use one primary and several secondaries. From an acoustical point of view, all the piezo-bar is used in transverse mode both for primary and secondaries. The frequency of operation is not necessary the first resonance of the bar (l/2) but can be higher (3l/2, 5l/2?) to optimize the electric field in the structure. For an electrical point of view, the obtained voltage ratio is dependent on the ratio of capacitors of primary and secondaries. But the electrical connections of secondaries are determinant and must be studied. We have developed a model of the piezoelectric transformer based on the 1D electrical equivalent circuit of a piezoelectric element. Then we have also used finite element software in 2D and 3D ATILA. The both calculus are interesting and complementary to understand the principle of our transformer and to approach different quantities like, strain, electric fields, voltage across secondaries.

The principle of our structure and the obtained results with the different models will be presented. A new method for optimizing the number of secondaries and the dimensions of the transformer using our modelisation will be also described.