Dynamic Modeling of Contact-Mode Triboelectric Generators by Lagrange’s Equations

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ABSTRACT

Electret based energy scavenging devices utilize electrostatic induction to convert mechanical energy into electrical energy. Uses for these devices include harvesting ambient energy in the environment and acting as sensors for a range of applications. These types of devices have been used in MEMS applications for over a decade. However, recently there is an interest in Triboelectric generators/harvesters, i.e., electret based harvesters that relies on triboelectrification as well as electrostatic induction. The literature is filled with a variety of designs for the latter devices, constructed from materials ranging from paper and thin films; rendering the generators lightweight, flexible and inexpensive. However, most of the design of these devices is ad-hoc and not based on exploiting the underlying physics that govern their behavior; the few models that exist neglect the coupled electromechanical behavior of the devices. Motivated by the lack of a comprehensive dynamic model of these devices this manuscript presents a Lagrangian formulation, electromechanical equation for a lumped parameter dynamic model of an electret-based harvester. The formulation is robust, capturing the effects of traditional MEMS devices as well as triboelectric generators. Exploiting numerical simulations the predictions are used to examine the behavior of electret based devices for a variety of loading conditions simulating real-world applications such as power scavengers under simple harmonic forcing and in pedestrian walking. Finally, the predictions from these models are compared with prototypes of paper-based generators.

KEYWORDS
Electret, Lagrangian, Triboelectric Generators, Energy Harvesting, Dynamic Modeling