Optimisation of an electromechanical energy harvester through multi-physics approach

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ABSTRACT

Energy harvesting is becoming every day more important since it can supply power to remote sensors and devices. Mechanical vibrations are among the different ambient energy sources that can be collected and exploited through different technologies like piezoelectric or electromechanical converters [1]. The analysis of the harvester performances is intrinsically multiphysics since it must take into account the primary energy source in the mechanical domain and the conversion system in electrical form. One kind of electromechanical harvesting devices is an electromagnetic linear generator. It is made by a magnet that can slide into a guide suspended between two elastic elements, both of classical or magnetic type, and by two coils that are wound around the guide with opposite polarity. Inertial forces, due to the vibrations, induce motion in the magnet and, consequently, cause a variation of the flux linkage in the coils. By electromagnetic induction a voltage is induced between the ends of the coils. The coil is connected to an electrical load through an electronic interface that conditions the harvested power and adapts it to the load requirements.

The dimensions of the device are usually constrained by the particular kind of application so that the power that can be retrieved by the device is efficiently expressed in terms of volume power density: high level of power density are required to fit the transducer inside existing structures or inside wearable devices. An optimisation of the device dimensions and of its electrical characteristics is thus crucial to adapt it to the particular excitations present in the environment: power density of the vibration, frequency spectrum, waveforms etc. [2].

To this aim a coupled electromechanical lumped parameter model of the structure has been developed that enables the simulation of the complete energy conversion chain. The theoretical model is able to take into account most of the nonlinear effects present inside the structure, ranging from the nonlinear viscoelasticity of the bump-stops that limit the stroke of the moving magnet, to the nonlinearities of the elastic elements etc. Notwithstanding its capabilities, the simulation tool is computationally efficient so that it can be inserted inside an automatic optimiser which drives the geometric and electric design variables towards the increase of the energy converted and delivered to the load. The main characteristics of the lumped parameters model and its application to the study and optimisation of an energy harvester applied to the supply of a wireless computer mouse will be presented.

REFERENCES

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