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DESIGN AND PERFORMANCE EVALUATION OF AN AEROELASTIC ENERGY HARVESTER BASED ON THE LIMIT CYCLE OSCILLATION PHENOMENON

Abstract

In the present era, the demand for low power electronic instruments has been increasing and their energy consumption is decreasing. With this increasing demand for low power electronics systems, the researchers focus on piezoelectric energy harvesting techniques, which is a process of converting mechanical energy into electrical energy. The possibility to extract energy from an operational environment is of great interest in the actual advanced industrial applications. This is particularly true in the aerospace field where energy saving is an absolute task and a network of wireless sensors for health management a very promising option. Indeed, being able to extract energy from the environment would permit to reduce the necessity of batteries thus reducing the weight of the overall system a fundamental task in the aerospace sector. Energy harvesting by fluid-structure interaction represents a significant research field for developing innovative solutions for power supply, a topic of well-known importance. In the present work, the possibility to extract energy by means of piezoelectric transduction from a post-critical aeroelastic behavior, as the Limit Cycle Oscillation (LCO), is investigated and a suitable designed aeroelastic device based on the use of piezoelectric components is presented. The nonlinearities giving the LCO will be considered in the structural part of the aeroelastic system whereas the aerodynamics will be considered as linear. Emphasis will be placed in demonstrating that a correct modeling of unsteadiness of aerodynamics is a critical ingredient for a sound prediction of the nonlinear behavior of an aeroelastic system and for correct evaluation of the performances of an energy harvester based on the LCO phenomenon. Indeed, the modelling of aerodynamics not only influences the prediction of the occurring of a LCO but also the prediction of its amplitude, which is directly connected to the amount of harvestable energy. Thus, the chosen aerodynamic model can strongly affect the prediction of the harvester performances used in the design. Different structural nonlinearities will be considered and compared in the design of the harvester as well as different piezoelectric materials and configurations. Finally, it will be shown that the designed device can be utilized to drive nano and microelectronics i.e., sensors in a wireless network.