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VIBRATION ANALYSIS OF PIEZOELASTIC SPACE-STRUCTURE FOR ENERGY HARVESTER

Abstract

Energy harvesting is the fundamental activity in most structure utilized for space exploration. In most if not many cases, it is not feasible to bring, along with probe, spacecraft or rover suitable supply of fuel to meet the energy needs for the mission. Some concepts of energy mining or other form of fuel production should be made, which could be provided by solar panels and storage batteries. It is with such motivation that the relatively micro-energy harvester may be able to provide additional energy supply, in particular for some instruments or apparatus in the space structure. To that end, we look at a typical Piezoelastic energy harvesters to convert the space structure vibrations into electrical energy. The availability and affordability of piezoelectric transducers offer a class of vibrating structure energy harvesters mostly in micro- to milliwatts scale which need to be tuned to match the characteristic frequencies. Following earlier similar work on Piezo-aeroelastic-electric transducer, the specific case considered will be the conversion of the vibration energy of a generic beam or foil of a space structure into electrical energy by a Piezoelastic-electric transducer. The present work presents the dynamics of a vibrating generic beam structure to be utilized as an oscillating beam energy converter. For propaedeutic analysis a generic piezo-aeroelastic cantilevered beam is defined and treated as a typical section. The basic governing equation of this generic structure is treated as a three degrees of freedom electro-dynamic system, with the first two-degree-of freedom comprising the standard elastic system with additional relevant terms to represent the influence of a piezoelectric embedded element on the cantilevered beam. Assuming and following the philosophical approach of binary vibrating system, the problem is mathematically formulated and solved for the range of solutions that can be obtained depending on the prevailing physical properties of the system, focusing on the stability characteristics of the generic system. The characteristic of the prevailing forcing function due to space structure motion and control system disturbances, the dynamics of the oscillating system associated with favorable energy harvesting capabilities are assessed.