High-energy Orbit Sliding Mode Control for Nonlinear Energy Harvesting

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Abstract

Vibration energy harvesting has extensive application prospects in many significant occasions, such as mechanical structure health monitoring, vehicle tire pressure monitoring, IoT devices and human health monitoring. The nonlinearity is an effective method to improve the energy harvesting efficiency where there are low- and high-energy orbits in the multi-solution region of the system. The harvested power will be increased significantly when the system is guided from the low-energy orbit to the high-energy orbit. However, previous research mainly focuses on the theoretical and numerical investigation of controlling strategy, but the feasibility of control methods has not been verified experimentally. This paper proposes a high-energy sliding mode control method through rotatable magnets actuated by micro-motor. The electromechanical model of mono-stable and bi-stable systems with the identified nonlinear restoring force is established to design a sliding mode control algorithm for enhancing the energy harvesting performance. Simulation and experiment results demonstrate that the rotatable magnets with sliding mode control have a positive influence on reaching the high-energy orbit for both mono-stable and bi-stable systems within the multi-solution region. Moreover, the rotatable magnets method with a sliding mode control actuates the small magnets in the system for a short time with little consumption of energy. This research has provided a practical application of high-energy orbit control for improvement of the energy harvesting.

Full Text

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