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On the Use of Discontinuous Nonlinear Bistable Dynamics to Increase the Responsiveness of Energy Harvesting Devices

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Highlights:

- Discontinuous Nonlinear Bistable Devices are investigated with equations of motion derived.
- Behavior of a proxy Discontinuous Nonlinear Bistable system parametrically studied.
- Discontinuous Nonlinear Bistable structures are shown to require less excitation than continuous bistable devices to reach the large-amplitude snap-through motion that is preferred for energy harvesting applications.
- Discontinuous Nonlinear Bistable structures are shown to respond to a broader excitation frequency range than continuous bistable devices to reach the large-amplitude snap-through motion that is preferred for energy harvesting applications.

Abstract

There is promise in the use of bistable devices to transduce ambient vibrations into electrical power. However, it is critical to sustain the relatively large amplitude snap-through motion, or interwell motion, to significantly improve the responsiveness of bistable devices as compared to linear resonance-based approaches. This work posits that relatively stiff structural elements can be placed in the vicinity of the equilibria of bistable devices such that the discontinuous change in dynamics will tend to eject an otherwise small amplitude motion into the large amplitude interwell orbit that is to be preferred for energy harvesting applications. The discontinuous nonlinear dynamic equations of motion are derived and a proxy system parametrically studied. These numerical studies demonstrate that discontinuous nonlinear bistable devices have a significantly broadened frequency range that elicits the large amplitude snap through behavior. It is also seen that interwell motion is achievable at significantly reduced excitation amplitudes through these discontinuous structural elements.