Vibration Mitigation of Multiple Nonlinear Resonances through an Analogous Piezoelectric Network

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ABSTRACT

Tuned vibration absorbers usually provide effective solutions for passive vibration mitigation. However, mechanical nonlinearities generate a detuning that seriously affects damping performance. A solution to this issue consists in the introduction of an additional nonlinearity in the absorber [1]. The interest of nonlinear piezoelectric shunts has already been proven for vibration mitigation of a single nonlinear resonance [2]. The present work addresses the development of a multimodal and fully passive piezoelectric tuned vibration absorber that mitigates several resonances of a nonlinear structure.

An analogous electrical network is assembled in order to reproduce the dynamics of a cantilever beam in the linear regime of motion. Several electrical resonances are simultaneously tuned to the mechanical resonances, thus providing the equivalent of a multimodal vibration absorber thanks to electromechanical coupling through an array of piezoelectric patches [3]. This allows broadband vibration mitigation at low forcing amplitudes. Yet, higher amplitudes still lead to a serious detuning of the absorber when considering nonlinear structures.

By extending a principle of similarity to spatial considerations, a nonlinear component is placed in the electrical network in order to mimic the dynamics of the mechanical structure. The electromechanical analogy is thus ensured beyond the linear regime. In this work, the use of a nonlinear capacitor generates an autonomous adjustment of the electrical resonances for a wide range of excitation amplitudes. The interest of this method is proved numerically and experimentally by mitigating vibrations over a broad frequency range that covers the first three modes of a beam with localised cubic nonlinearity.

REFERENCES

[1] Habib, G. and Kerschen, G. A principle of similarity for nonlinear vibration absorbers. *Physica D* (2016) **332**:1–8.

[2] Lossouarn, B., Deü, J. F. and Kerschen, G. A fully passive nonlinear piezoelectric vibration absorber. *Phil. Trans. R. Soc. A* (2018) **376**:20170142.

[3] Lossouarn, B., Deü, J. F. and Aucejo, M. Multimodal vibration damping of a beam with a periodic array of piezoelectric patches connected to a passive electrical network. *Smart Mater. Struct.* (2015) **24**:115037.