Active nonlinear energy sink using integral force feedback under steady regime

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Abstract: Excessive vibrations in mechanical structures can cause many problems such as reducing structural integrity and compromising the commissioning of precise instruments. Tuned mass dampers (TMDs) are often employed to suppress undesirable vibrations. However, they are known to be effective only in a frequency band limited around one vibration mode and to be sensitive to the detuning of primary structures. Alternatively, nonlinear energy sinks (NES) can be used as they do not have a preferential resonance frequency, making them more robust to detuning and capable of damping multiple resonances. In this paper, the performance of an active nonlinear energy sink (ANES) is investigated, which is realised using a novel integral force feedback controller. Unlike the traditional NES, which is realised by a cubic spring, a dashpot and an inertial mass, the proposed ANES is equivalent to a mechanical system which consists of a cube root inerter, a dashpot and a linear spring. Because of the full analogy with a mechanical network, the system is unconditionally stable. Moreover, the ANES can be easily configured and implemented for different applications compared to the traditional NES. The effects of control parameters i.e. cube root inertance, linear stiffness, viscous damping, and amplitude of the external excitation, on the performance of the proposed ANES is examined based on the analytical solutions. The harmonic balance method is employed to approximate the analytical solutions and numerical simulations is performed to validate the analytical solutions.