Accurate calibration of RL shunts for piezoelectric vibration damping of flexible structures

Piezoelectric RL (resistive-inductive) shunts are passive resonant devices used for damping of dominant vibration modes of a flexible structure and their efficiency relies on precise calibration of the shunt components. In the present paper improved calibration accuracy is attained by an extension of the local piezoelectric transducer displacement by two additional terms, representing the flexibility and inertia contributions from the residual vibration modes, not explicitly targeted by the shunt damping. This results in an augmented dynamic model for the targeted resonant vibration mode, in which the residual contributions, represented by two correction factors, modify both the apparent transducer capacitance and the shunt impedance. Explicit expressions for the correction of the shunt circuit inductance and resistance are presented in a form that is generally applicable to calibration formulae derived on the basis of an assumed single-mode structure, in which the modal interaction has been deliberately neglected. A design procedure is devised and subsequently verified by numerical examples, demonstrating that effective mitigation can be obtained for an arbitrary vibration mode when the residual mode correction is included in the calibration of the RL shunt.