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PIEZOELECTRIC RL SHUNT DAMPING OF FLEXIBLE STRUCTURES

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Summary: Piezoelectric transducers are used in various applications for damping and control of the dynamic response of flexible structures. In particular resonant piezoelectric RL shunt circuits have been used for structural damping because in many engineering cases they secure an acceptable compromise between efficiency and robustness, provided that the individual components of the RL shunt circuit are calibrated appropriately.

The performance of resonant damping concepts is often sensitive to even a small detuning of the resonant filter parameters and in particular the filter frequency. The calibration of resonant damping strategies typically relies on an approximate single mode representation of the flexible structure dynamics. For mechanical vibration absorbers or tuned mass dampers this is often an accurate representation because inertia based devices operate with respect to absolute structural motion, whereby they are located where the influence from non-resonant vibration modes is limited. This is different for piezoelectric transducers, which operate on the local deformation of the dynamic structure. Thus, piezoelectric transducers are commonly positioned where the interaction with the non-resonant vibration modes is significant. This implies that the performance of piezoelectric RL shunt damping depends on a precise parameter calibration, and therefore indirectly on the accurate representation of the interaction with the non-resonant modes of the flexible structure.

The influence of this residual mode interaction is directly taken into account by a quasi-static representation of the structure motion from the non-resonant vibration forms. It is demonstrated how this leads to explicit expressions for the equal modal damping calibration of the resonant RL shunt circuit components, where the correction for the influence from non-resonant vibration modes appears via a single background flexibility parameter. The calibration procedure extends that recently proposed for calibration of resonant mechanical vibration absorbers. It is demonstrated by numerical examples that both equal modal damping and a flat plateau in the frequency response amplitudes of the flexible structure are attained, provided that the proposed background flexibility correction is taken into account in the calibration of the shunt circuit components.