Resonance frequency detuning (RFD) is a piezoelectric-based vibration reduction approach that applies to systems experiencing transient excitation through the system’s resonance for example, turbomachinery experiencing changes in rotation speed, such as on spool-up and spool-down. This technique relies on the inclusion of piezoelectric material and manipulation of its electrical boundary conditions, which control the stiffness of the piezoelectric material. Resonance frequency detuning exploits this effect by intelligently switching between the open-circuit (high stiffness) and short-circuit (low stiffness) conditions as the excitation approaches resonance, subsequently shifting the natural frequency to avoid this resonance crossing and limit the response. The peak response dynamics are then determined by the system’s sweep rate, modal damping ratio, electromechanical coupling coefficient, and, most importantly, the trigger (represented here in terms of excitation frequency) that initiates the stiffness state switch.

This thesis identifies the optimal frequency-based switch trigger over a range of sweep rates, damping ratios, and electromechanical coupling coefficients. With perfect knowledge of the system, the optimal frequency-based switch trigger decreases approximately linearly with the square of the coupling coefficient. Furthermore, phase of vibration at the time of the switch has a very small effect; switching on peak strain energy is marginally optimal. In practice, perfect knowledge is unrealistic and an alternate switch trigger based on an easily measurable parameter is necessary. As such, this thesis also investigates potential methods using the open-circuit piezoelectric response envelope and its derivatives. The optimal switch triggers collapse to a near linear trend when measured against the response envelope derivatives and, subsequently, an empirical control law is extracted. This control law agrees well with and produces a comparable response to that of the optimal control determined using perfect and complete knowledge of the system.

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The public is welcome to attend.