Vibration Control using Shunted Piezoelectric and Electromagnetic Transducers

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To my parents
Rick and Sally Behrens

Declaration

I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

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Abstract

Mechanical structures encounter vibration in response to environmental conditions and dynamic loads. In most circumstances, vibration contributes to mechanical fatigue which can eventually lead to catastrophic failure. Consequently, vibration control is a necessity for prolonging the operational life of structures.

Piezoelectric and electromagnetic transducers have been used for control of vibration for many years. They normally sense mechanical vibration and generate an opposing vibration through another piezoelectric and electromagnetic transducer. This is usually referred to as active feedback vibration control.

Another vibration control strategy senses and actuates simultaneously through an appropriately designed electrical impedance which is connected to the terminals of a single transducer. This technique requires no additional sensor, has improved robustness and stability, and a similar feedback structure compared to active feedback vibration control.

The objective of this thesis is to develop new vibration control techniques by expanding on both the previously mentioned strategies.

The first part of this thesis considers connecting an electrical impedance to a piezoelectric transducer to control vibration. This part reinforces that this vibration control strategy can be modelled as a variation of active feedback vibration control whereby the impedance parameterises the effective controller. A series of new vibration controllers are then presented.

Applying the knowledge gained in the first part of this thesis, the second part considers replacing the piezoelectric transducer with an electromagnetic transducer. Although the underlying dynamics and physical properties of the transducers are different, the feedback structures are remarkably similar to that of active feedback vibration control. A number of new vibration control strategies are proposed for a variety of mechanical systems.

Throughout the thesis, theoretical ideas and concepts are experimentally compared and validated on simple mechanical apparatuses to evaluate their vibration control performance.

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