

Some issues in active vibration control of smart structures

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Abstract

The paper is divided into three parts.

The first one is devoted to the active damping of structures with collocated actuator/sensor pairs; the paper first discusses the benefit of the collocated architecture and its consequence on stability and robustness with respect to structural changes. The particular case of a piezoelectric actuator collocated with a force sensor is considered; the attractive properties of the (decentralized) Integral Force Feedback (IFF) are emphasized and simple criteria to assist in performance prediction are presented; the method is illustrated with various examples belonging to space, precision engineering and civil engineering projects; it is shown that the same control strategy can be applied to solve problems with vastly different amplitudes and can be implemented with drastically different technologies, namely piezoelectric actuators for space structures and precision engineering, and hydraulics for civil engineering applications.

The second part is concerned with vibration isolation; two implementations of the celebrated sky-hook single-axis isolator are discussed and compared; the first one is the classical one based on acceleration sensing (acceleration feedback) and the second one is based on the measurement of the total force transmitted by the isolator (force feedback); it is shown that the force feedback implementation benefits from alternating poles and zeros which allows a control law with guaranteed stability, making it very attractive when the payload to be isolated from the disturbance source is very flexible, such as in large space structures. Next, a six-axis isolator based on the architecture of a cubic Stewart platform is discussed in the context of space applications; the control strategy is based on decentralized force feedback. The closed loop behaviour of the ideal isolator is first studied and the deviation from this ideal behaviour due to technological constraints is discussed next; the close relation between performance and technology is emphasized.

The third part is devoted to spatial filtering and the use of spatial filters in structural control. There are two broad ways to achieve spatial filtering: (i) discrete sensor arrays and (ii) distributed sensors. Discrete array sensors are reconfigurable and can be used to construct modal filters as well as to tailor open-loop frequency response functions to achieve desirable properties; however, they are prone to spatial aliasing,

which is responsible for a lack of roll-off at high frequency and has a strong negative impact on the closed-loop performance of control systems. Distributed sensors are not subject to spatial aliasing, but they are not reconfigurable. In this paper, we focus on piezoelectric (PVDF) films; a porous electrode design is described, which allows the tailoring of the equivalent piezoelectric properties of piezo films to achieve a wide class of distributed filters. The concept is demonstrated by the construction of a volume velocity sensor of a baffled plate.

References:

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