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A velocity based active vibration control of hysteretic systems

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ABSTRACT

Hysteresis is a property of systems that do not instantly follow the forces applied to them, but react slowly, or do not return completely to their original state. A velocity based active vibration control, along with a special class of hysteretic models using passive functions are presented in this paper. This hysteretic model is based on a modification of the Bouc–Wen model, where a nonlinear term is replaced by a passive function. The proposed class retains the rate-independence property of the original Bouc–Wen model, and it is able to reproduce several kinds of hysteretic loops that cannot be reproduced with the original Bouc–Wen model. Using this class of hysteretic models, a chattering velocity-based active vibration control scheme is developed to mitigate seismic perturbations on hysteretic base-isolated structures. Our hysteretic model is used because of its simplicity in proving the stability of the closed-loop system; i.e., a controller is designed using the proposed model, and its performance is tested on the original hysteretic system, modeled with Bouc–Wen. Numerical experiments show the robustness and efficiency of the proposed control algorithm.

1. Introduction

The physical property called hysteresis can be defined as a memory-dependent (and also path-dependent) relation between excitation and response. It is a natural phenomenon encountered in a wide variety of processes like biology, optics, electronics, ferroelectricity, magnetism, mechanics, and structural systems, among other areas [1,2]. On structural systems, hysteresis appears as a natural reaction of materials used to supply restoring forces against movements to dissipate energy [3]. Models of hysteresis have been reported, for instance, in [4–8]. Within the fields of civil and mechanical engineering, the Bouc–Wen model has been extensively employed to describe the hysteresis behavior of these systems [1,3]. However, this dynamic model is quite complex as it has seven unknown parameters, which are not completely linearizable; this could represent a problem in the control design. Despite the versatility of the Bouc–Wen model in describing several hysteresis loops, this model cannot describe, for instance, asymmetric loops [9,6], the tendency of change of hysteretic loops [10], pinching-like behavior, initial residual strain [11], or the Stribeck effect [12]. Based on Bouc–Wen model, we present a generalization of it that captures these behaviors, not losing the Bouc–Wen model properties. On the other hand, for the purpose of maintaining the seismic response of structures within safety, service and comfort limits, the combination of base isolators and feedback controllers (applying forces to the base) has been proposed

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