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Backstepping Boundary Control for Vibration Suppression of the Undamped Shear Beam with Sliding base

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Abstract

This paper presents a backstepping boundary control for suppression of vibration of the mechanical systems. In this research, we use a shear beam with sliding base as a plant. The applications are such as space structure, industrial robotic arm etc. Most slender beams can be modeled using the shear beam. The shear beam is more complex than the conventional Euler-Bernoulli beam in that a shear deformation is additionally taken into account. The method allows us to deal directly with the beam's partial differential equations (PDEs) without resorting to approximations. An observer is used to estimate the deflections along the beam. Gain kernel of the system is calculated and then used in the control law. The control set-up is anti-collocation. Finite difference equations are used to solve the PDEs and the partial integro-differential equations (PIDEs). Numerical results for the control of a shear beam are presented via computer simulation to verify that the control scheme is effective. Control parameters are also varied to see their influences that affect the control performance.

Keywords: Backstepping boundary control, Shear beam, Partial differential equations, Gain kernels, Observer, Finite difference equations

1. Introduction

Flexible beams constitute an important problem in many applications such as space structures, industrial robotic arms, cantilever cranes, helicopter rotor, astronomical telescopes, the atomic force microscope (AFM) in nanotechnology devices etc. In this paper, we consider a model of the undamped shear beam. Most of the slender beams can be represented by this model. The beam system is distributed parameter in nature, so it's governed by partial differential equations (PDEs). The model consists of a wave equation coupled with a second-order-in-space ODE or can be alternatively represented as a fourth-order-in-space/second order-in-time PDE. The shear beam is more complex than the Euler–Bernoulli model and slightly simpler than the Timoshenko model. There are many models for flexible beams such as Euler-Bernoulli, Rayleigh, shear and Timoshenko beam equations. Derivations and comparisons of these beam models can be found in [1].