VIBRATION CONTROL OF A SMART STRUCTURE USING PERIODIC OUTPUT FEEDBACK TECHNIQUE

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ABSTRACT

Active vibration control is an important problem in structures. One of the ways to tackle this problem is to make the structure smart, adaptive and self-controlling. The objective of active vibration control is to reduce the vibration of a system by automatic modification of the system's structural response. This work features the modeling and design of a Periodic Output Feedback (POF) control technique for the vibration control of a smart flexible cantilever beam system for a Single Input Single Output case. A POF controller is designed for the beam by bonding patches of piezoelectric layer as sensor / actuator to the master structure at different locations along the length of the beam. The entire structure is modeled in state space form using the Finite Element Method by dividing the structure into 3, 4, 5 elements, thus giving rise to three types of systems, viz., system 1 (beam divided into 3 finite elements), system 2 (4 finite elements), system 3 (5 finite elements).

POF controllers are designed for the above three types of systems for different sensor / actuator locations along the length of the beam by retaining the first two vibratory modes. The smart cantilever beam model is developed using the concept of piezoelectric bonding and Euler-Bernoulli theory principles. The effect of placing the sensor / actuator at various locations along the length of the beam for all the three types of systems considered is observed and the conclusions are drawn for the best performance and for the smallest magnitude of the control input required to control the vibrations of the beam. The tip displacements with the controller is obtained. Performance of the system is also observed by retaining the first 3 vibratory modes and the conclusions are drawn.

KeyWords: Smart structure, finite element model, state space model, periodic output feedback, vibration control.

I. INTRODUCTION

Vibration control of any system is always a formidable challenge for a designer. Active control of vibrations relieves a designer from strengthening the structure from dynamic forces and the structure itself from extra weight and cost. The need for intelligent structures such as smart structures arises from the high performance requirements of such structural members in numerous applications. Intelligent structures are those which incorporate actuators and sensors that are highly integrated into the structure and have structural functionality, as well as highly integrated control logic, signal conditioning and power amplification electronics [4].

An active vibration control system consists of an actuator, controller, sensor and the system / plant (beam) which is to be controlled [5]. Fully active actuators like Piezoelectrics, M R fluids, Piezoceramics, Electro-rheological fluids, Shape Memory Alloys, PVDF can be used to generate a secondary vibrational response in a linear mechanical system. This could reduce the overall response of the system plant by destructive interference.