Investigating the Stability of a Strongly Nonlinear Structure Through Shaker Dynamics in Fixed Frequency Sine Tests

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Abstract. Recent research has demonstrated developments to apply experimental continuation using the force dropout phenomena and fixed frequency voltage control sine tests to stabilize a nonlinear system through shaker dynamics. This approach has been demonstrated to stabilize the unstable response of a strongly nonlinear system near resonance. Recent fixed frequency voltage control tests on a strongly nonlinear system with a vibro-impact nonlinearity has revealed unexpected jumping behavior, like that seen during force controlled swept and stepped sine testing. In this research, the stabilizing effects of an electromechanical shaker coupled to a strongly nonlinear structure are investigated in fixed frequency voltage control tests using both numerical and experimental methods.

Introduction

Common experimental force control methods used for nonlinear dynamical testing such as stepped and swept sine testing often leads to imperfect quality in the control parameter and or bifurcations leading to the so-called jump-down or jump-up phenomena between stable solutions. Control algorithms such as control-based continuation [1] and phase-locked loop [2] have been used to control through the turning point bifurcations during nonlinear testing to measure the unstable branch which is of interest for model validation and calibration. Recent research has demonstrated the successful development of a sine testing method to obtain the unstable portion of the multivalued response curves of strongly nonlinear systems utilizing open-loop voltage control [3]. The purpose of this study is to investigate and identify the stabilizing parameters of an electromechanical shaker coupled to a nonlinear structure in numerical and experimental tests by utilizing the force drop-out phenomena in fixed frequency voltage control tests demonstrated in [3].

Results and Discussion

The numerical results suggested that there were various stabilizing parameters in the electromechanical shaker. However, the back electromotive force on the shaker produced by the relative velocity of the shaker body and armature was the one variable that strongly influenced the stabilizing effect of the shaker. The stabilizing effect from this parameter was also observed in experimental testing on a strongly nonlinear system suggesting there was strong corroboration between the numerical and experimental results. This study will help understand the stability of nonlinear systems that are coupled to electromechanical shakers.

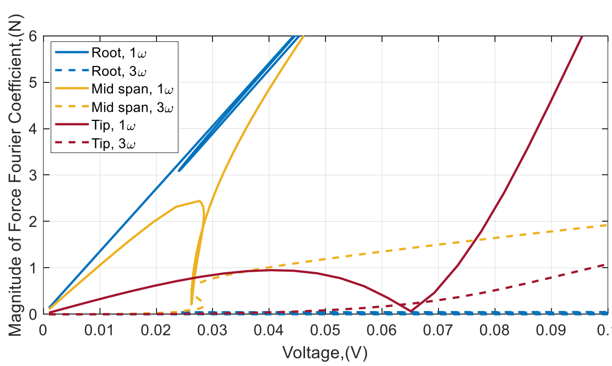

Figure 1. Parametric study revealing unstable and stable behaviors from different shaker drive points on a nonlinear beam

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