Dynamic Response of Aero-Servo-Elastic System with Nonlinear Elements

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Abstract

Linear structural dynamics, unsteady aerodynamics, control system and actuator models are combined for linear aero-servo-elastic equations of motion that are augmented with nonlinear feedback loops based on the Increased-Order Modeling approach. While the linear equations are formulated in the frequency domain for best combined efficiency, accuracy and robustness in industrial environment, the nonlinear feedback loops are modeled in the time domain to provide maximal flexibility in adding nonlinear effects in all the involved disciplines. The linear equations are solved first to provide a baseline response to deterministic or stochastic gusts, maneuver commands or direct-force excitations using FFT techniques. Nonlinear effects are then added in a time-marching process that modifies the linear solution using convolution integrals. The numerical process was utilized in the Dynresp code that was recently developed as a framework for industrial applications and research in the area of nonlinear structural dynamics. The procedure is outlined with emphasis on structural nonlinearities using a fictitious-mass technique. The numerical example exhibits limit-cycle oscillations due to actuator nonlinearities.