TITLE: Stochastic response of nonlinear systems with fractional elements

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ABSTRACT:

Fractional calculus has become a quite useful tool in theoretical and applied mechanics, especially in the development of non-local continuum mechanics theories, and viscoelastic rheological modelling. As an example, viscoelastic dampers used for vibration control, or for seismic isolation purposes, can be effectively modelled via a fractional order model of its behavior. The fractional derivative operator is a generalization to the integer-order operator with memory-persistent attributes. Due to its integral-based definition, any differential problem involving fractional derivatives is theoretically infinite dimensional. For this reason, specific solution strategies are pursued in the literature to address the deterministic dynamic response analysis of systems endowed with fractional derivative terms. However, it is noted that dynamic actions on vibrating systems are often stochastic in nature, and nonstationary in time. Further research in the field of the development of efficient solution schemes for the determination of the nonstationary stochastic response of such systems is, therefore, desirable. In this regard an approach developed in conjunction with the Statistical Linearization technique is proposed. The method resorts to harmonic balancing in deriving response-amplitude dependent equivalent damping and stiffness. The expected values of these parameters are considered, in proceeding to formulate a Statistical Linearization solution approach. The solution procedure is completed by integrating in time the Lyapunov equation associated with the derived equivalent linear system. The advantage of this approach relates to the particularly fast evaluation of the transient response statistics, if juxtaposed with the efficiency of techniques involving augmentation of the dimension of the requisite equivalent linear system.