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Stochastic response determination and optimization of a class of nonlinear electromechanical energy harvesters: A Wiener path integral approach

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Abstract

A methodology based on the Wiener path integral technique (WPI) is developed for stochastic response determination and optimization of a class of nonlinear electromechanical energy harvesters. To this aim, first, the WPI technique is extended to address the particular form of the coupled electromechanical governing equations, which possess a singular diffusion matrix. Specifically, a constrained variational problem is formulated and solved for determining the joint response probability density function (PDF) of the nonlinear energy harvesters. This is done either by resorting to a Lagrange multipliers approach, or by utilizing the nullspace of the constraint equation. Next, the herein extended WPI technique is coupled with an appropriate optimization algorithm for determining optimal energy harvester parameters. It is shown that due to the relatively high accuracy exhibited in determining the joint response PDF, the WPI technique is particularly well-suited for constrained optimization problems, where the constraint refers to low probability events (e.g. probabilities of failure). In this regard, the WPI technique outperforms significantly an alternative statistical linearization solution treatment commonly utilized in the literature, which fails to capture even basic features of the response PDF. This inadequacy of statistical linearization becomes even more prevalent in cases of

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