World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:12, No:03, 2018

Investigating the Energy Harvesting Potential of a Pitch-Plunge Airfoil Subjected to Fluctuating Wind

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Abstract : Recent studies in the literature have shown that randomly fluctuating wind flows can give rise to a distinct regime of pre-flutter oscillations called intermittency. Intermittency is characterized by the presence of sporadic bursts of high amplitude oscillations interspersed amidst low-amplitude aperiodic fluctuations. The focus of this study is on investigating the energy harvesting potential of these intermittent oscillations. Available literature has by and large devoted its attention on extracting energy from flutter oscillations. The possibility of harvesting energy from pre-flutter regimes have remained largely unexplored. However, extracting energy from violent flutter oscillations can be severely detrimental to the structural integrity of airfoil structures. Consequently, investigating the relatively stable pre-flutter responses for energy extraction applications is of practical importance. The present study is devoted towards addressing these concerns. A pitch-plunge airfoil with cubic hardening nonlinearity in the plunge and pitch degree of freedom is considered. The input flow fluctuations are modelled using a sinusoidal term with randomly perturbed frequencies. An electromagnetic coupling is provided to the pitch-plunge equations, such that, energy from the wind induced vibrations of the structural response are extracted. With the mean flow speed as the bifurcation parameter, a fourth order Runge-Kutta based time marching algorithm is used to solve the governing aeroelastic equations with electro-magnetic coupling. The harnessed energy from the intermittency regime is presented and the results are discussed in comparison to that obtained from the flutter regime. The insights from this study could be useful in health monitoring of aeroelastic structures.

Keywords : aeroelasticity, energy harvesting, intermittency, randomly fluctuating flows
Conference Title : ICWE 2018 : International Conference on Wind Engineering
Conference Location : Prague, Czechia
Conference Dates : March 22-23, 2018