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Modelling and Experimentation of a Two-DoF Piezoelectric Energy Harvester under Vortex-Induced Vibration

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Abstract

Vortex induced vibrations are considered a viable renewable source that can be utilized to run wireless remote sensors. Scientists proposed several methods to harness the energy from the vortex-induced vibrations and convert it to electrical power. This research aims to design and test a two degrees of freedom piezoelectric energy harvester that converts the harvested energy from vortex-induced vibrations into electrical power. In addition, the research aims to develop a dynamic mathematical model of the proposed energy harvester. The enhancement of the operating bandwidth and amplitude of the harvester power output is prioritized. The proposed model is tested inside wind tunnel to capture the oscillations bandwidth and amplitude. The gathered experimental results are compared to the simulated results to validate the developed mathematical model. The proposed energy harvester has a cantilever beam arrangement with a Styrofoam bluff body at its free end. The two degrees of freedom system is achieved by having inner beam inside the main cantilever beam and attaching a mass to its tip. The experimental results showed that adding a secondary oscillator increases the operating bandwidth and amplitude of the piezoelectric energy harvester. Further, the lock-in phenomena contributed to increasing the bandwidth which can be achieved by having a low mass bluff body. The low mass bluff body resulted in reducing the mass ratio which allowed the lock-in phenomenon to occur. The comparison between the experimental results and the model simulated results showed a good matching especially in the resonance frequency and lacked the ability to predict the peaks amplitudes accurately. In addition, parametric study conducted looking at the effect of the secondary oscillator position and the optimum resistance load that maximizes the power output.