Abstract

In the current study, harvesting energy from the airflow is achieved by using the galloping instability in the prismatic structures with the help of piezoelectric material. A geometrically non-linear distributed parameter model has been developed for galloping based piezoelectric energy harvesters (GPEH) and validated by using experimental data from the literature. The transverse force involved with galloping is modeled by using quasi-steady aerodynamic theory and represented by the polynomial function of angle of attack. It is seen that the order of polynomial governs the type of bifurcation and the stability of the dynamic system. It is also found that a minimum 7^{th} order polynomial is needed to predict the system response accurately. An artificial neural network (ANN) based approach is proposed to improve the accuracy and avoid the nonlinearity involved with 7^{th} order polynomial in calculating the galloping force. A robust numerical approach is needed to handle large nonlinearities involved with aerodynamic force. Therefore, a finite element (FE) model is developed considering both geometric linearity and nonlinearity. The coupled FE system equations are solved by using the code generated in the MATLAB environment. The geometrical nonlinearity is found to be insignificant and the linear model is sufficient to predict the system output accurately. Further, the effects of vertical inclination of the square prism on the performance of the energy harvester are investigated by using the proposed FE model. Furthermore, stochastic analysis is carried out by using Monte Carlo simulation (MCS) and polynomial neural network (PNN) to find the effects of uncertainty in system parameters (Aerodynamic, Mechanical, Electrical, Electromechanical) on the electrical power output. The accuracy and adaptability of the PNN model are established by comparing the results with the Monte Carlo simulation (MCS). A sensitivity analysis has also been conducted to find the influence of individual and combined input parameters on the power output. Finally, an experimental setup is prepared to demonstrate the concept of energy harvesting

using GPEH system. An electronic circuit is proposed to charge the cell phone battery using the power output from the energy harvester.

Keywords: Energy harvesting, Nonlinear dynamics, Finite element modeling, Galloping, Piezoelectricity.